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WATER SUPPLY IN TIME OF WAR

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In today's urgent pressure of serious affairs, a problem to which a minimum of specific attention seems to be directed by government is the important problem of water supply. It is taken for granted, as it commonly is by the average citizen, that there will be water, plenty of water, and good safe water whenever and wherever it is needed. In most situations, fortunately, there is plenty of good water. It is worth while, however, to examine the problem in its different phases, and to see what needs to be done, in time of war or threat of war, to make sure that water supply for the civil population and for industry is safeguarded and to make provision for water of suitable quality and quantity to take care of the aggregations of men and animals, called armies, and of all the numerous facilities, normally non-existent in peace time, that serve the armies.

Water supply in time of war may conveniently be considered in the following categories:

1. In established cities and towns.
2. In camps, hospitals, ports, railroads, supply depots, etc., serving the armies.
3. In combatant zones.

1. *Water Supply in Established Cities and Towns.* A heavy responsibility rests upon the water supply official of an established community in war time. Without neglecting any of his customary important duties, he must give his close attention to the following:

He must be on the alert. The operation of many, perhaps of most, established water supply systems not lying within a combatant zone will follow the even tenor of its way through a war emergency. The responsible water supply official will not bank on this, however. The risks of damage from sabotage will be ever present. An inter-

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ruption of supply may have tragic results in paralyzing industrial production. He must therefore always be alert, actively and aggressively alert, in the discharge not only of his ordinary duties, but especially of those duties which devolve upon him as the result of a war emergency.

He must do everything possible to anticipate and prevent sabotage. Damage due to sabotage appears to be one of the things most likely to happen in a situation where subversive agents see the possibilities of causing delays in industrial production for defense and confusion or demoralization among people. He must give special study to the points in the system vulnerable to damage either by sabotage, by shell fire, by bombs, or by any phase of military operations and must have a procedure studiously planned for making good such damage, should it occur, with the least possible delay. He must have his organization instructed and, if possible, drilled in such procedure and should carry in stock any materials, equipment or parts not quickly obtainable, yet vital to the rapid repair of the damage.

He must make every effort to anticipate the need for water for industrial purposes arising out of suddenly developed war industries and must do everything possible to assure that the required supply will be available when wanted, quickly enough to prevent any war industry from suffering shortage. He must carry through an inquiry designed to assure his prompt and definite knowledge as to where vital materials or parts may be obtained and also where experienced repair services may be had, and how quickly, in the event of emergency need.

The water supply profession is already alive to the need of attention to this first category of water supply needs. The editorial staff of *Engineering News-Record* has for some time past been discussing this matter with water works engineers and superintendents. The substance of this discussion appeared in the issue of that journal for July 18, 1940. It enlarges in considerable detail upon the foregoing and can be read to advantage in conjunction with this paper.

This Association has a Committee on Water Works Emergencies which has only recently rendered its first report. While the emergency of war was not foremost in the minds of this Committee as they compiled their report, there is nevertheless much therein that is pertinent to the safeguarding of established water supplies that may be exposed

to the menace of war damage. The fact, too, that the Maine Water Utilities Association, at their August meeting, had a round table discussion on preparation against sabotage and that the Pennsylvania Water Works Association was recently addressed on this topic furnishes additional evidence of the active interest that is currently being taken in this vital subject.

In established cities and towns, the facilities already exist, and likewise the organization, to furnish any quantity of good water within the capacity of the system. Also, the procedure for increasing the supply to meet new needs arising from war activities is known to municipal officials and can be put into effect, if needed, without the intervention of any agency of the Army.

For the many and varied water needs of the Army, on the other hand, in combatant zones and in military utilities, organizations for the construction and operation of water facilities must be brought into action, with men selected for their experience in water works and provided with all the machinery, plant and materials necessary for building emergency and field water supply systems.

2. *Water Supply in Camps, etc.* A port to be used by an army is usually at or near a city with developed water supply facilities. Water requirements for the port may be obtained from the existing supply. It is not unlikely, however, that intensity of war activity or increase in tonnage to be handled may result in a demand for water in excess of that which can be furnished by the city. In such a situation it would be necessary to develop additional supply.

A railroad to be used in a theater of war is most likely to be one that is already established. It may be well equipped with water supply facilities for the peak traffic it is normally called upon to handle; yet the peak traffic due to war activities may call for greatly increased water supply facilities. It may or may not be feasible to solve this problem as part of some other water supply problem in the same area and, if not, an additional supply must be developed.

A supply depot, if not occupying an ample existing area and facilities in a city or a town, is likely to have to be located anew in a rural location. In such a situation the water supply facilities, of course, would have to be newly developed.

Hospitals will frequently be placed in available buildings in cities where adequate water supply facilities already exist. In large military

operations there are almost certain to be large hospitals established in rural areas where no water supply facilities exist and new facilities must, of course, be provided.

The word "camp" covers a wide variety of temporary and semi-permanent living quarters for combatant or service troops. In a great many cases, camps cannot count upon water supplies already developed, and special provision has to be made for them.

Unless established where they can enjoy the advantage of adequate existing municipal supply, all such situations, involving urgent demands for indispensable water upon which the success of military operations and service operations depends, must be taken care of by an organization that has ample authority, necessary labor, equipment and materials, or the means of procurement without delay. In the theater of war, the army must have this authority in its own hands, since in the ordinary case civil authority does not have the means of quickly obtaining the required results in strict accordance with military requirements.

There are two army agencies that undertake water supply work, namely, the Engineer Department and the Quartermaster Department. In general, within an established field of military operations, the providing of wholesale water supply is an Engineer function. In the construction of new port facilities, railroads, hospitals, etc., in the A.E.F., all of the work, including water supply, was done under the direction of the Engineer Department. On the other hand, in the construction of the numerous cantonments in the United States in 1917, such as Camp Dix or Camp Devens, all of the work, including water supply, was done under the direction of the Constructing Quartermaster.

When our armies take the field for military operations, there is provision for the creation of Engineer Battalions for Water Supply, one for each Army. This is explained more in detail further on. The duty of such an Engineer Battalion is to assure ample and safe wholesale water supply for all units of the Army in the combatant zone. The same principle may be extended, as an Engineer function, throughout the lines of communication. For all other situations, in general, arrangements for assuring an ample water supply for military units are a function of the Quartermaster General's Department.

3. *Water Supply in Combatant Zones.* In military operations

the soldier has to attend to what might be called "retail supply" of water for himself. In the field, the smaller tactical units send details of men, with suitable containers, to carry water for the units. Thus the kitchens, the chow wagons, are supplied, the Lyster bags are filled up, and the men replenish their canteens when they can. These details of men have to know where to go for water, and there has to be an adequate and safe supply made available for them, if it is not already available. These sources, which are in effect the "wholesale supply" must be within a reasonable distance of every tactical unit which has to send there for water.

An army would indeed be fortunate if water were already available in this wholesale form at points where all troop details could go and get it. To such an extent as it is not available, it must be made so. This providing of wholesale water supply is the function of an army water supply service.

Thus the retail water supply problem for an army requires no special organization and no special equipment but merely man power and suitable water containers. The wholesale water supply problem for an army, however, necessitates a highly specialized organization of men experienced in the various branches of water supply work and equipment and material adapted to the exacting requirements of producing good safe water for troops to drink.

In wars prior to that in France, 1914-1918, there does not appear to have been any unit serving an army for the express purpose of providing ample supply of water safe for troops to drink. The conditions of that war resulted in the creation of such units in various of the armies in the field, including the American Expeditionary Force.

Experience in the A. E. F. showed that an army water supply service should consist of the following:

A regiment of army water supply troops
A water tank train
A mobile repair unit for motor transport
A general engineer depot shop train and trucks
Additional labor troops
Additional officers for staff and special duty
Water supply laboratories

All of these should have complete personnel and equipment. There was much work that necessitated labor troops in addition to

engineer troops with specialized training. The water tank train assured wholesale delivery of water to forward water points to which pipe lines had not been laid. Motor trucks and cars were kept in condition by the mobile repair unit. The various jobs of mechanical work in connection with pumps, piping, water treatment apparatus, etc., were taken care of by the shop trucks.

The one regiment of army water supply troops that got into service in the A.E.F. was the 26th Engineers. It had a normal strength of about 1600 men. Including Sanitary Corps officers and other attached officers, there were about 75 officers in the organization. With few exceptions, the officers were men who had had considerable experience in water supply work. The enlisted personnel included a great many men who likewise were experienced in one branch or another of water supply work, such as well drillers, pipe fitters, pump men, carpenters, and concrete workers. For efficiency, such an organization must of course be made up of men who have had practical experience.

Water Supply Troops Are Army Troops. Procurement of a water supply is peculiarly dependent upon geographical, topographical and hydrological conditions. It is definitely a regional matter. It must therefore have a regional basis in its application to the water supply problem for troops in the field.

Divisions are mobile, and the tendency is to make them more mobile rather than less. The territorial jurisdiction of the divisional commanding officer and divisional engineer officer is transitory. In moving into a new area they are sure to be extremely busy with other functions that pertain primarily to tactical problems. The geographical boundary of a Division may be changed by order at any hour. A water supply development may be under way before a Division comes in, continued during its presence, and sometimes completed after the Division has left a given area. The Division furthermore has a right to expect work of this sort to be done for it by some other agency and should not be burdened with responsibility for this development. These principles are illustrated by the fact that various parts of the Water Supply Regiment in the A.E.F. carried out their specialized duties in 38 areas occupied temporarily by combat Divisions.

The Corps is less mobile than the Division. It is, however, still

mobile in the sense that its geographical boundaries may change often, especially in connection with great activity. This may be accomplished in a manner different from the bodily movement of the Division into or out of an area; perhaps by orders that alter the number of Divisions in a given Corps, or some other relatively simple procedure that has the effect of altering the territorial boundaries of its jurisdiction. If water supply troops and water supply officers belong to Corps, there would then result a sudden change in jurisdiction that could be accomplished only with difficulty and lost motion, in changing the control of work that pertains so distinctly to the area, rather than to the tactical unit. Such changes as this would be most likely to occur at times of great activity. Then, of all times, continuity of control is of dominating importance to maintain.

Further, it is recognized that in the development of water supply work, one system may with advantage supply troops in two Corps areas on opposite sides of the common boundary line between Corps, due to topographical or geographical conditions. Pipe lines may cross these boundaries. One pumping station may serve points in two areas. An ample source may be available on one side of the boundary line and nothing readily available on the other side. It must also be recognized that it would be purely accidental if the geographical boundary of Corps or Division happened to conform to the topographical condition that might govern a field water supply development.

For these various reasons it is logical to place the responsibility and the authority for the development of water supply in the hands of engineers attached to Army. It is, of course, necessary in doing this to safeguard adequately all tactical units to make sure that their rights and authority shall always be aided and never impaired by the designation of engineers of Army to handle water supply. Whatever activities of the water supply organization relate to police and traffic control and to measures for safety near the front must be regulated by Division or Corps.

Control of Quality of Army Water Supplies. The Medical Department has always had highly important responsibilities in assuring that water used by troops is safe for them to drink. Medical responsibility has in the past been directed primarily to control of quality of the "retail supply". The Lyster bag and the standard ampule of hypochlorite were among the outstanding features of the program of quality control.

For several decades past, water supply engineering practice in the United States has given complete consideration and attention to water supply laboratory work as necessary to assuring municipalities good safe drinking water. The laboratory examination, sanitary inspection, and other phases that pertain primarily to the question of water quality, are so intimately related to the design, construction and operation of works that it is not practical to separate them. In civil practice, these functions have all come to be a part of the engineering work. Engineers engaged in water supply problems have come to have a comprehensive knowledge of quality control, including the necessary laboratory work.

As the engineers who were charged with water supply responsibility in the A.E.F. were fully prepared to discharge all these responsibilities, and as the inherent responsibility of the Medical Department must not be infringed upon, it became necessary to have the respective duties of the Engineer Department and of the Medical Department of the A.E.F. clearly defined. In the A.E.F., the division of responsibility in water supply matters was first defined in G.O. 34, G.H.Q. 1918, which was later modified to make it clearer and more comprehensive as G.O. 131, G.H.Q. 1918. At the same time a G.H.Q. bulletin of instructions, No. 55, 1918, was published, giving in ample detail the organization, functions and duties of the Water Supply Service.

Briefly, these provided that the water supply organization would make available adequate quantities of water at water points located as conveniently for the troops as the conditions would reasonably permit, and in as pure a state as practicable, using filtration or disinfection or both, as circumstances might justify; the medical officers attached to tactical units to attend to such subsequent disinfection treatment as the water might require, in Lyster bags, in water wagons, tanks, or reservoirs from which water will be drawn by troop details or individuals for direct consumption.

This basis was logical, since the responsibility of the water supply service in the construction of works and in the delivery and handling of water terminated at the water points; whereas, the responsibility for the carrying of water to the final points of use, in cans or pails or water wagons, rested upon the tactical units themselves.

As these two documents are of historic interest and formed the basis for the successful operation of the Water Supply Service in the A.E.F., they are attached to this paper as appendices.

Numerous questions of procedure regarding points of mutual interest to the Engineer Department and the Medical Department were raised in the course of the discussion. The defining of responsibility in the general orders made it necessary to make the authority coincide, so that officers engaged in the discharge of Engineer Department functions would be assigned to and be responsible to that department. The occasion for specifying this arose out of the development in the Engineer Department, as a branch of the Water Supply Service, of the laboratory and sanitary inspection branch. Much of its personnel was drawn from the Sanitary Corps of the Medical Department, and some of the water supply laboratories were located in Medical Department laboratories, where otherwise there would have been a duplication of facilities.

This official designation of responsibility and authority did not interfere with the services of the officers of the laboratory branch, being of the maximum usefulness to the Medical Department as well as to the Engineer Department. With a full recognition that the water supply problem is one that involves the interests of both departments in a peculiar way, the duties of the laboratory branch were intended to include everything that either the Engineer Department or the Medical Department might want to cover in connection with questions relating to the quality of water supplies, and all information regarding the quality of water supplies was made fully available to the Medical Department as well as to the Engineer Department.

The most careful consideration was given to this rather mixed problem in the A.E.F., and the Medical Department was freely consulted with a view to arranging a procedure that would be understood and recognized as sound by both departments.

Materials and Equipment. The success of water supply work for an army depends first of all upon a supply of materials of constructions. Those engaged in field operations cannot hope for a maximum of correctness and convenience in the material placed at their disposal. The conditions under which the procurement of materials is accomplished in war time may not assure that pipe threads or flanges will always match, or that motors will always correspond to voltages

available. Water supply engineering in field operations is to a large extent crude and hurried. The successful water supply officer is one who can build the required water facilities to conform to the operations program, build them rapidly, and overcome any difficulties he may find in building them out of the materials that he happens to find available.

The utmost care must nevertheless be taken to assure the best possible supply of materials and equipment that can be made available to water supply troops under the varied and often difficult conditions of field operations. The time factor is usually short, and the length of even this short time available for the preparation of water facilities is likely in many cases to be quite unknown to the water supply officer. Procurement of materials takes time. Delivery of materials to dumps in the theater of war takes time. In the emergency of war there are a thousand items contending for priority, both of procurement and of delivery.

Individual effort may to some extent at least be helpless in the face of staff efforts to do those things first which are of prior military necessity. The water supply officer may at best have a limited control or perhaps little or no control over the reservation of any engineering materials for the use of the water supply service, if there happens to be a demand for those materials to fulfill some military necessity that staff departments consider more immediately urgent.

A judgment has to be formed as early as possible as to the class of equipment and materials needed for field operations. Carefully compiled lists must be prepared and put through appropriate channels for procurement requisitions. Consideration has to be given as to what items on these requisitions should be automatically repeated, that is, procurement of given qualities at fixed intervals of time.

For the water supply service as perhaps for any other special service, the best possible arrangement should then be worked out between the representatives of that service and of the supply department with a view to assuring the maximum possible reservation of water supply materials for water supply service consistent with staff requirements for taking care of urgent military necessity as it develops.

In the A.E.F., an experienced officer of the water supply regiment was relieved from duty therewith, and assigned to the supply section of the Office of the Chief Engineer for the purpose of aiding the water

supply service in every legitimate way in matters relating to materials and equipment.

Conditions Affecting Army Water Supply Work. The foregoing statements rest on experience in water supply work in the A.E.F. In another war emergency the conditions might differ greatly from those which prevailed in 1918. Armies everywhere throughout history have depended to a very large extent on existing water supply. This they can nearly always do to some extent and are undoubtedly doing in many of the combatant areas that now dot the world. Their ability to do this may be restricted. If a large army contemplates operations in a theater of war in which available water supplies are scanty, it may be quite impossible to carry on without making definite provision for assuring an adequate supply of water for men and animals.

One of the extreme cases of this sort was the campaign of the British, 1914-1918, sometimes defensive and sometimes offensive, against the Turkish army in the desert region lying east of the Suez Canal. Here the operations they carried through to eventual success would have been quite impossible without the development of water supply and water transportation abreast of the army in its desert operations.

In a theater of war where developed supplies do not afford easily available water points for troops, an army will be faced with the problem of making adequate provision for wholesale water supply. Whether they can do this or not, or the degrees to which they can do it with reasonable satisfaction, depends upon various things. It depends upon the factor of time available. It depends upon the character of the warfare, whether it is defensive or offensive, and the rate of movement of armies. It depends upon the size of armies involved. It depends upon the character of the country. It depends not only upon the number of men in the field armies, but also the number of animals, and this is a very important factor. Fundamentally, of course, it depends upon the natural resources of water available in the way of streams, lakes or ponds, springs and wells.

The warfare of rapid movement which has been so conspicuous a feature of recent operations in Europe has for the most part been a movement through well watered and densely populated regions. Probably there was no possibility and likewise probably there was little or no need for the provision of wholesale water supply facilities

such as was made with such care during a good part of the war in France, 1914 to 1918. Military operations of that kind lessen the opportunity to make such provision while also lessening the need.

If such a military movement were carried out through a country that was arid or undeveloped or both, it is likely that lack of water or lack of opportunity to develop water points as rapidly as the operation could progress might easily restrict the speed of the operation and also the distance it could carry.

If opposing armies are more or less evenly matched as to numbers, armament and leadership, it may result as in 1914 to 1918 in warfare stationary for long periods. This condition obviously permits an extensive development of field water supply.

Engineer Battalion, Water Supply, U. S. Army. Whatever the nature of the warfare, whatever the conditions in the theater of war, the United States Army plans to be prepared to deal effectively with the problem of wholesale water supply for troops in the field. One step in preparation for this has been the establishment of tables of organization for "Engineer Battalion, Water Supply", and its component parts. In early July, 1917, not even a table of organization for a water supply unit existed. The Army today has the advantage of the A.E.F. experience in water supply, and the very complete and detailed reports that were made at the end of those operations. Upon authorization of special service engineer troops for a field army, the appropriate water supply unit could be created and put in the field with a minimum of delay.

The Engineer Battalion, Water Supply, consists of 25 officers and 628 enlisted men. It includes battalion headquarters of 4 officers; headquarters and service company, 2 officers and 80 men; 3 companies, each having 4 officers and 172 men; and attached medical personnel, 7 officers and 32 men. Each of the 3 companies is divided into 3 platoons. Two of these consist of 2 tank truck sections of 9 trucks each for water transportation. The third platoon consists of 3 sections, 1 for installation, 1 for water purification, and 1 tank truck section of 9 trucks. The purification section is furnished with a mobile water purification unit, and the personnel of the section includes a water supply engineer, an engine man and a filter operator. Besides the purification section of each engineer company (3 to the battalion) there are 6 mobile water purification units, complete with personnel, forming the purification section of the headquarters and service company.

It is contemplated that one engineer battalion for water supply will serve one field army. Additional battalions may be provided, to be under the orders of the G.H.Q. An engineer battalion with a field army then has these units at its service:

3 installation sections.
9 mobile water purification units, each with operating crew.
135 2½ ton, 500-gal. water tank trucks, each with operating crew.
14 ¾-ton, 2-wheel cargo trailers.
15 ½-ton pick-up trucks.
4 5-passenger cars.
1 motor cycle
1 field ambulance.

Among the attached medical personnel of the battalion, 2 Captains and 1 First Lieutenant may be officers of the Sanitary Corps, and 4 enlisted men with specialist ratings are to be laboratory technicians.

The mobile water purification unit is a complete self-contained unit designed to deliver up to 6000 gal. per hour of potable water. There is a centrifugal pump driven by a gasoline engine, capacity 100 g.p.m. at 90-ft. head. There is a pressure filter, with tanks for alum and soda ash solutions, and a chlorinator. There is a small laboratory unit, sufficient to assure that the water is maintained at the required standards. All this is mounted on a 2½- or 3-ton truck.

Notwithstanding the arrangements just described, which stand on the records as the present established method for providing wholesale water supply for troops, there is a tendency towards a change in part at least. An easily portable type of water treatment plant for the use of troops has been developed. This type of equipment is not listed as part of the equipment of the Water Supply Battalion. Up to the present time it has been used on maneuvers in this country.

Each unit consists of a gasoline-engine-driven centrifugal pump of 40-g.p.m. capacity against a 50-ft. head, a hypochlorite solution feed, 2 chemical feed tanks, a container for hypochlorite solution, and tools and accessories, all mounted on a light pipe frame. Also a small pressure filter which is intended to be used if the water needs clarifying.

Equipment of this sort can be provided in quantity and issued to tactical units in suitable numbers. Where troops are in the neighborhood of natural sources of water supply—streams, ponds, springs, etc.

—even though polluted, they can set up their portable purification equipment and produce safe water at a rate of 1000 gal. per hour, or more. A few of these equipments will take care of a lot of men and animals. To such an extent as field conditions permit this to be done, the providing of wholesale water supply becomes tactical.

Armies frequently operate in regions where adequate natural sources of water do not exist within convenient reach of tactical units. In such locations, and in fact in all locations, responsibility for making sure that troops will have wholesale water cannot be divided. The Army Water Supply Service has to satisfy itself that tactical units can find local sources of water supply wherein to set up their portable equipment. If Army cannot satisfy itself of that, then production of water supply by tactical units for themselves is out the window and Army has to make provision. If Army, trusting to tactical units to supply themselves, omits to make wholesale provision where the tactical units cannot, the High Command is likely to have something to say about it through the Inspector General's Department. In other words, the fundamental responsibility for assuring that men and animals do not go thirsty rests in the last analysis upon Water Supply Service of Army.

Thus is our army prepared to take care of its water supply problems. When faced with the conditions in any theater of war, it may develop that different or additional organization and equipment may be needed. Well drilling equipment may be indicated. Pumps will surely be urgently needed, and piping, fittings, tanks, canvas, etc. In a serious emergency it seems likely that additional labor troops would be made available, as installation sections of only 17 men appear quite inadequate for some installation jobs. The Engineer Battalion, Water Supply, however, will serve as the flexible nucleus for whatever water supply work is required.

Like any phase of war, water supply work has its hazards. This is illustrated by the British experience in 1918. The German offensive that summer pushed the British back, and the enemy occupied very large areas vacated by the British. The movement was hurried so that the British did not remove pumps or other facilities at field pumping stations. The westward sweep of the enemy resulted also in the loss of certain British dumps in which was located their well drilling equipment. Due to the nature of the country in which they were located, the British had to be able to drill wells. Right after the loss

of their equipment to the enemy, British G.H.Q. sent a representative to American G.H.Q. to try to borrow some well drilling equipment. Fortunately the latter had it and could spare it, and shortly thereafter part of it was delivered over to the British. Before the end of summer the British had driven the enemy back and reoccupied the territory previously lost. Virtually none of the well drilling equipment and pumping units they had lost was recovered.

The hazards to water supply operations with any army are further illustrated by an experience during the latter half of 1918 on the French Front. The offensive launched against the French in 1918 swept them back across the valleys of the Vesle and the Aisne in the region north of Chateau Thierry. In this area there was a network of electric power lines. When the enemy was pushed back to the north and east again later in the summer and American troops aiding the French sought to establish water systems with electrically operated pumps, it was found that all the French power lines had been stripped of copper by the enemy.

Water supply operations with an active field army are arduous and highly responsible and call for the loyal service of men who recognize no limits to energy and ingenuity. Their vital tasks are often in most dangerous positions. With the complete lack of knowledge that sometimes exists as to how much time is available to finish a job, they may have to work in relays day and night. The difficulties of supply of materials, transportation, shortness of time, and inclement weather contribute to making it a difficult job.

The soldier gets very little appreciation for his service to his country, no matter how dangerous, arduous, and distasteful it may have been, or what sacrifice it may have entailed. He has the laudations of his friends; he has the inward satisfaction of having done his share in the duty of defense; he has the compensation, in one form or another, to which the soldier is entitled, but that is little enough and soon gone. Government as such is too impersonal to express appreciation in a manner to warm the human heart. To the loyal soldier the greatest satisfaction, of course, is a sense of hazardous duty well performed.

I know, however, that men's hearts do warm to the recognition of duty well done, and because I had the opportunity to observe how well done were the duties of providing wholesale water supply in the A.E.F., I cannot resist the impulse to express the impression I had at

that time and still have that the success attained during the emergency in making wholesale provision of water for troops was due to a rare sense of duty and a rare combination of abilities on the part of all of the officers and men involved in that work, and marvelous team work throughout. Their success in this endeavor is perhaps best indicated by the statement made by the Commander-in-Chief that he had at no time heard of any shortage of water for the troops.

APPENDIX

G.H.Q.
AMERICAN EXPEDITIONARY FORCES.

FRANCE, August 7, 1918.

General Orders
No. 131

1. . . .

2. The responsibility for water supply work for the A.E.F. is divided as follows:

(a) In the army zones special engineer troops (water supply) assigned to armies shall be responsible for the supply of adequate quantities of water at "water points" located as conveniently for the troops as service conditions will permit. This water will, if necessary, be purified by filtration or disinfection, or both, in such a manner as to insure the delivery of water of the best quality practicably obtainable under the conditions.

(b) In all areas occupied by the American troops outside of army zones, the Engineer Department will be responsible for the development, as required, of water supplies for the use of American troops and for American activities of every kind. This water will be given such treatment as the conditions demand and permit.

(c) All water to be used by American Troops shall be considered of doubtful quality, and, when required for human consumption, shall be treated, unless proven good by a succession of satisfactory examinations and laboratory tests. Water-analysis laboratory facilities will be provided, generally as sections of the Medical Department laboratories, and will be in charge of officers of the Engineer Department (Water Supply Section), who will conduct examinations and laboratory tests. The proper officer of the Engineer Department will report to the proper officer of the Medical Department the results of water analyses as made.

(d) The Medical Department will be responsible for any disinfection treatment that water may require beyond "water points", and, to prevent contamination and pollution, will supervise its handling and the care of containers so that the water will finally be safe for consumption by troops.

By command of General Pershing:

James W. McAndrew, *Chief of Staff.*

OFFICIAL:
Robert C. Davis, *Adjutant-General.*

G.H.Q.
AMERICAN EXPEDITIONARY FORCES.

FRANCE, August 8, 1918.

Bulletin
No. 55

A.—Organization of Water Supply Service.

1. The Water Supply Service of the American Expeditionary Forces is organized as a branch of the Engineer Department. It consists of certain officers and special engineer troops experienced in water-supply work, including examinations, design and construction. Its duties are defined by Sec. 1, G.O. No. 131, G.H.Q., A.E.F. 1918.

For each army the Water Supply Service will consist of army engineer troops (not to exceed one regimental headquarters and six companies), especially trained and equipped for water-supply work, and such additional officers as conditions may require.

In general, the functions of the army water-supply organization will include the investigation of water resources, the development of water supply, and the construction and operation of such works as may be necessary to make water available at "water points", including conveniences for watering animals, filling water carts, water-tank trains, buckets, canteens, and other containers. Tactical units will make provision for the transportation of water from "water points" to the final point of consumption.

The commanding officer of the Water Supply Regiment will normally be the Water Supply Officer of the army, serving as an assistant to the Chief Engineer of the army. He will anticipate and make suitable provision to meet the water-supply needs of the army, and will exercise such technical supervision and control over water-supply work in the entire area occupied by the army as may be necessary to coördinate water-supply developments and economize time, material, and labor. Under the direction of the Chief Engineer of the army he will direct laboratory and sanitary inspections necessary to determine potability and to prevent contamination.

Under the direction of the Chief Engineer of the army, the work of installation, maintenance, and repair of power pumping equipment incidental to the development of "water points" will be done by engineers of the electrical and mechanical or other units according to conditions, but such equipment will be operated in accordance with the requirement of the water-supply organization.

Water-supply troops are army troops as differentiated from division or corps engineer troops. When working in army areas they will perform their work and be under the direct control of the Chief Engineer of the army acting under instructions from Army Headquarters. To properly perform their duties, water-supply troops must acquire an intimate knowledge of the area in which they are to operate, and must be thoroughly familiar with layout and mechanical details of water-supply installations serving the area. In the interests of efficiency, therefore, these troops should be used continuously in the same sector and on the same class of work, in so far as other military requirements will permit. They will not be moved except upon instructions from Army Headquarters.

When operating within sectors assigned to corps, division, or other tactical commands, the relation between water-supply troops and other engineer organizations of these commands will be the usual relation existing between army troops and corps or division troops, namely: Officers of the Water Supply Service, when in local charge of work lying within the territorial jurisdiction of these commands:

1st. Will at all times be prepared to furnish, upon request by corps or division engineers, information concerning their work in hand and future projects.

2d. Will secure the approval of corps or division engineers upon questions of installation and operation, as far as tactical considerations are involved, but will report direct to the Chief Engineer, Army, upon all technical matters.

3d. Will, upon request, advise corps and division engineers on technical matters pertaining to the Water Supply Service, and perform such technical work as may be consistent with the work assigned to them by the Chief Engineer, Army. Whenever the performance of work requested by corps or division engineers will conflict with work already assigned by the Chief Engineer, Army, or known to be under immediate consideration, the local water-supply officer will, before proceeding, request approval from the Chief Engineer, Army, and will advise the corps or division engineer of action taken, and the reason therefor.

Nothing in these instructions shall be construed to deprive the commanding officer of the corps, division, or other command, of the authority that is fundamentally vested in him, such as police and traffic control, arrangements for subsistence and supply, and enforcement of measures for safety.

Discussion

Edward J. Cleary.* Colonel Longley has clearly indicated that waterworks men are facing a situation today for which there is no precedent. The forces of destruction which so-called total war has loosed, envelop more than the zones of actual combat. Therefore, we cannot reflect upon experiences before and during the last World War period and simply upon these base a pattern for present activities. To prepare adequately for whatever may be before us in safeguarding water supplies, calls for a broader perspective and new thinking. And, I might add, partisan interests should not be permitted to stand in the way of adopting suitable safeguards; in this connection I refer specifically to the recent difficulties encountered by New York City in seeking to curtail public fishing in its reservoirs.

Sabotage of water supplies as a means of paralyzing industrial production is no myth, and evidence exists that such efforts already have been attempted in this country. Further, it was told to me on good authority that as far back as the ill-fated Munich conference,

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the British Intelligence Service had discovered elaborate plans for sabotage of water utilities as a means of demoralizing community morale. No one, perhaps, can better appreciate the terrible effectiveness of such activity than the members of this audience whose everyday business concerns itself with problems of water service.

To that which has already been said and written concerning precautionary measures, I would add this suggestion—immediate steps should be taken to provide leadership in this movement. And it is in this regard that an unusual opportunity exists for our state sanitary engineers to coördinate and emphasize the adoption of safeguards. In fact, I would go farther to say that they represent the logical agencies to assume aggressive leadership in this vital campaign.

Here are the principal reasons why: (1) Many state sanitary engineers have already perfected organization plans and techniques for dealing with emergencies such as floods and earthquakes, and thus they are ideally equipped and ready to cope with sabotage emergencies; and (2) the state engineers are familiar with the personnel, the plants, and the problems of water purveyors in their respective areas. In other words, each state may be considered as already having an established clearing house for the collection and dissemination of information on water supply sabotage protection.

In this connection it would seem to be in order to point out that possibly the state sanitary engineers might come to an arrangement with the Federal Bureau of Investigation working toward mutual objectives of plant protection. When and if it should become necessary for the federal government to participate in municipal water supply sabotage precautions, it certainly will be more desirable to work with a group of 48 established and specially qualified representatives than to set up a new and separate agency attempting to represent the 12,800 waterworks in this country.

There is one point more that I wish to emphasize. It is simply this: Many of the precautionary measures that should be undertaken by municipal water authorities are nothing more than the extension of normal improvement work as dictated by good practice. For instance, the installation of extra valves to isolate promptly sections of the system, or the improvement of distribution piping for better capacity and pressures are deficiencies that eventually will have to be corrected. Any other measures that are taken to insure reliable water service such as completing maps and records or training crews in the prompt

handling of emergency repairs are highly desirable regardless of present conditions.

There is nothing to lose—but everything to gain—by preparing to cope with sabotage. And waterworks managers never had stronger reason to plead for funds and authority to go ahead with the betterments that every system needs. The community which puts its water system in the best possible working order now has the added satisfaction of performing a patriotic duty.

W. A. HARDENBERGH.* The division of responsibility for water procurement and purification among three services of the Army—the Quartermaster Corps, the Corps of Engineers and the Medical Department—has some elements of awkwardness in it, and may, in a degree, be responsible for the slow progress that has been made in furnishing to the soldier in the field the kind of water that he is accustomed to at home. Whatever the cause, the doughboy has had to accept some very second-rate water in the past; and too often he has had to provide it for himself.

The Quartermaster Corps is responsible for the construction, maintenance and operation of water purification plants and distribution systems, and for the quantity and quality of water, at all stations, camps and installations in times of peace; and in the Zone of the Interior, that is, in this country, in times of war.

The Corps of Engineers is responsible for the supply of water in the Theater of Operations to army divisions, to smaller units where practicable, and to fixed installations, such as hospital centers, supply depots, etc.

The Medical Department is responsible for the health of the troops and is therefore charged with the duty of making surveys, inspections and examinations of water supplies, and of preparing recommendations for equipment and procedures necessary for producing a safe water. It also makes bacteriological and chemical analyses of the water and has the responsibility for supervising the procurement and purification of temporary field water supplies.

Thus, among the three services charged with water supply duties, there is no provision for field purification, except that the Medical Department, which has no equipment for water treatment, must supervise what is done.

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The quality of field water supplies does not appear to have been given adequate consideration. The soldier in the field has often been required to drink turbid, odorous and overchlorinated water. This is not necessary for if the will to do so is available, the soldier can be supplied with water that is both safe and attractive except under the most unusual conditions. A factor in this has been that few regular army men have had any opportunity to become acquainted with the possibilities of modern water purification.

The now obsolete mobile water purification unit and the new portable filter, both described by Colonel Longley, are used by the Army, not as filters, but merely as strainers. It is true that alum and soda ash are added just before the water reaches the filter, but those who operate water filter plants will appreciate how little good is accomplished by this procedure, and what their own difficulties would be in producing a satisfactory water if they adopted the same method, eliminating coagulation and settling entirely. An extra pump, a portable storage tank to provide sedimentation, and a small amount of coagulant would greatly increase the efficiency of these filter units, and would permit normal production of a clear water, even from turbid sources.

It is a pleasure to note that the Engineer Board has recently taken steps to improve the treatment facilities for field water supplies, and that both responsibility and suitable equipment for the treatment of what Colonel Longley terms retail water supplies may soon be a fact.

The provision of field supplies is now being complicated by the greater mobility, and consequent greater dispersion, of troops under the conditions of mechanized warfare. And yet it seems possible that this complication may, in the end, make the problem a much simpler one.

Under World War conditions, men were concentrated or massed to such an extent that local water supplies were seldom sufficient in quantity. Sources had to be developed and water hauled to the front. The example frequently used to illustrate the problems of retail water supplies in the pre-mechanized age of warfare is as follows:

A battalion, roughly 800 men, is holding a front line position; and in this case we will assume that the outpost line, about three-quarters of a mile further to the front, is held by 50 men from the battalion. These 800 men will require 1,800 to 2,000 gallons per day of water for drinking and cooking. Battalion water supply equipment

consists of Lyster bags (1 per 100 men or fraction thereof) and four 110-gal. mule-drawn water carts. Simple arithmetic will show that about 16 cartloads of water must be provided each 24 hours. The water carts are usually filled at water points in the rear and brought up with the first load as soon as possible after dark. More arithmetic will show that each cart must make four round trips between the water point and the troops, and that the distance covered in the four round trips must not be more than a mule can travel between dark and dawn. Assuming this to be 16 miles, the water points must not be more than 2 miles from the front line. The wholesale supply system has to deliver to these water points.

But even with the water at the battalion line, there still remains the problem of getting water forward to the outpost. Satisfactory methods of carrying this water forward have not been developed. At present, the plan is to carry it forward in milk cans; though awkward and difficult, there seems to be no better method.

The advent of mechanization has brought a new set of problems. A battalion may now be 10 or 20 miles to the front or flank, and the mule is in the discard. To supply the troops, it is necessary either to provide highly mobile tank trucks that can haul water to these rapidly moving columns, or to utilize local supplies more freely. If mobile tank trucks are used, it will be difficult to make contact, for moving columns on strange roads at night are not easy to locate; and there is always the chance that, in this modern war of movement with formations spread out loosely, an enemy unit may penetrate into the lines and intercept or delay the water supply tanks. There is also the chance that delivery may be delayed or prevented by damaged or blocked roads or destroyed bridges.

The World War American division contained 27,000 men; our modern mechanized divisions about 12,000. In addition to the smaller numbers, mechanization brings a marked reduction in density of troops, an army is more scattered, there are fewer men per unit of area, and very few animals. These facts favor the use of such local supplies as wells, springs, cisterns and small streams. It seems desirable, therefore, to provide each important element of the Army with its own water procurement and purification equipment. At present, it is felt that there should be at least four water treatment units per triangular division—one for each combat team and one in reserve; and it is at least possible that smaller units of the army could advan-

tageously be self-contained, so far as water supply and purification are concerned.

A pack filter has been developed that is suitable for outposts and for small detachments. It weighs 34 lbs., is designed to be carried on a man's back, and has a capacity of about 2 g.p.m. It is operated by a hand pump; the filter material is paper padding, though other filter media can be used. With the standard paper pads, all turbidity and nearly all bacteria are removed. Waters that are high in turbidity clog the filter rather quickly; therefore, some preliminary treatment as settling or coagulation and settling is desirable with turbid waters.

A water procurement and purification unit to serve a combat team, regiment or smaller unit should be based on the army portable filter. To supplement it, there should be portable canvas sedimentation and storage basins; light weight pumps; hose, purification chemicals; and 2 or 3 of the pack filters. The whole unit could be mounted on a light truck or trailer and accompany any mobile mechanized force. Maximum use could be made of local supplies, and clear and attractive water could be produced under almost any conditions.

The light-weight, mobile, fully-equipped unit described may replace the wholesale water supply system described by Col. Longley, but would be more likely to supplement it. However, if mechanization and air trends continue, the bulk of an army is likely to be held in reserve in rear areas to permit concentration for attack, or to meet attacks. Under these conditions, wholesale water supply might function, but it seems more likely that the necessities for concealment and protection against aircraft would dictate that the troops be spread out, in which case local supplies might be utilized. With motor transportation, troops do not have to be grouped compactly, since the greater mobility permits concentration quickly.

At the present time we have had insufficient experience in all of the phases of mechanized warfare, and field water supply problems cannot be considered as wholly solved. The portable filters, serving comparatively small units, were very satisfactory in the 1940 maneuvers, and definitely won a place in army water supply. Changes have already been recommended by the Army Engineer Board, covering equipment and method of use of the Water Supply Battalion, and additional personnel recommended for Engineer regiments for filter unit operation.

For some years the engineers of the Sanitary Corps have been

engaged in developing methods for the detection, neutralization and removal of warfare gases from water. If water supplies should become contaminated with certain of the so-called poison gases, as mustard, a problem of a serious and important nature would be created. In coöperation with the Chemical Warfare Service, much experimental work has been done, including the development of tests, feeding experiments, and methods of removal for various types of gases. The procedures developed for treatment are essentially in line with standard water purification practices and in case of threat or emergency would be made available to all water supply plants. Except in unusual cases, gas contamination can be neutralized or removed so as to eliminate any danger from the use of the water; and in many or most cases even the accompanying tastes and odors can be removed.

Water supplies for camps and cantonments should present no serious problem, so far as either construction or operation is concerned. The present considerable expansion of the army, with the consequent enlargement of some existing camps and the opening of new ones, will require both extensions and enlargements and some new supplies. However, our preparedness is not war, and the relatively simple problems involved do not need any discussion here.

A. H. PRATT.* Colonel Longley, as a graduate of the U. S. Military Academy, later resigned from the Army, and for years associated with one of the most distinguished consulting water engineering firms of the country, was especially well qualified to undertake the responsibility of Chief of the Water Service in the A.E.F. His skill and tact in adjusting the very delicate relations between the sanitary engineer and the medical man was an outstanding contribution. The high regard in which he was held by those in authority at G.H.Q. enabled him to influence them in the adoption of a sound water supply doctrine and gave assurance that the water supply service in the field would be adequately supported in high quarters, thus preventing its submergence at times by those locally "in command" and outranking the water supply officer.

As a commander of water supply troops in the field, the writer was in a position to observe Colonel Longley's success in seeing that experienced personnel and adequate equipment reached the water supply troops. His services to his country well justified the award of

*Consulting Engineer, Newark, N. J.

the Distinguished Service Medal which was made on May 3, 1919. It is to be hoped that in the present emergency the War Department will be equally wise or fortunate in the selection of a person for any similar position in the new army.

It is appropriate that this Association should recognize this subject in the present emergency, for had it not been for the interest and support of this Association the publishing of the History of the 26th Engineers[1] and thus making a permanent record of its service would doubtless have been impossible. There is regrettably not time to tell the story which is very much to the credit of the Association.

The author has prepared a very complete outline of the various factors to be given consideration in connection with water supply in time of war. The first part of his paper is replete with sound comment of value to those now in charge of existing civilian water supplies. While we are not now technically at war, it would be most encouraging if we could prove that democracy could protect itself 100% against the saboteur. Such protection will cost money, and money is hard to get as any water works superintendent knows. But how much better to protect our vital water supplies in advance than to wait until some damage is actually done and then try to recover our neglect.

The writer had no experience with camp water supplies in the U. S during the War but will discuss briefly a few features supplementing matter in the paper concerning water supply with the armies.

The doctrine of a separate Water Supply Service as a branch of the Engineer Department in the A.EF. is clearly described by the author and is detailed in the classic Bulletin 55 and General Order 131, and it is very good that both of these publications have been added to the author's paper for consideration at this time. Except in connection with the History of the 26th Engineers previously mentioned, these documents are not readily accessible. It should be noted, however, that this doctrine is not universally accepted in the Army. The new Engineer Battalion, Water Supply, in the present tables of organization quoted by the author is a case in point. Here the regiment is cut to a battalion with the resulting reduction in specialist personnel and reduction in rank of the commanding officer and consequent loss of prestige.

The writer after the War was assigned to the command of one of these battalions as a reserve officer—on paper, of course, and he

[1]See this JOURNAL, XXXIII, 569 (1919).

tried to instil in his command the principles enunciated in the paper, but officers without A.E.F. experience in the water service might not have been so well equipped.

While the War Department recognized the "very satisfactory service" of the special troops in the World War, it has been stated[2] that it "was ideally suited to the character of warfare which prevailed in 1918."

"The Kellar Board report (1919) which forms the basis of the present Engineer Organization, did not provide special water supply troops other than the water supply battalion, which is a water transportation unit and takes the place of the old *water tank trains*.

"The present engineer set-up contemplates decentralized operation and that the various engineers will take care of the water requirements within the areas.

"If the above . . . is not suited for a particular condition water-supply work may be exempted from control of district commanders and a water supply service organized."

This is an abstract of the doctrine of many Engineer officers of the regular Army that engineer troops are qualified to do anything and that there is no place for the specialist in war. The writer cannot help but note with pride, however, that the efficiency of the 26th Engineers has been recognized by the former enemy in German language technical military journals.[3]

Unquestionably the outstanding item of equipment of the 26th Engineers was the Mobile Water Purification Unit described in the paper. This water purification plant mounted on an auto-truck was enthusiastically acclaimed wherever seen. Not only Engineer officers but commanders of high combat units urged assignment of these trucks whenever advance operations were planned, and there were never enough to meet the demand. They were built by the well-known firm of Wallace & Tiernan, I believe, first for the British, were improved in design as a result of combat experience and changes have continued up to the present time. The most recent photographs in the *Military Engineer*, of September, 1940, show a truck with lower clearance and with more compact equipment than the World War design. The present issue is there stated to be one for each engineer battalion, regiment or separate company. These recent maneuver

[2]Major S. L. Scott, *The Military Engineer*, May, 1929.
[3]See Heerestechnik. Monatschrift für alle technischen Fragen des Reichsheeres, Feb. 1930.

photographs also show what appear to be the old A.E.F. canvas tanks erected on a platform for elevated water storage.

Colonel Longley mentions the water supply problems of the British in Egypt. These have been described in British publications. A supply of filtered water was extended from Kantara on the Suez Canal to the field of battle near Beersheba, a distance of 147 miles. Pipes were of 8- to 12-in. diameter with booster pumps about every 24 miles. In the attack on Beersheba the following troops were supplied: 3 mounted divisions, 1 camel corps brigade, 7 infantry divisions, 1 brigade of composite troops, G.H.Q.

Water was supplied by rail at a rate of	120,000 g.p.d. (U. S.)
Water was supplied by pipe at a rate of	190,000 g.p.d.
Local wells were developed at a rate of	120,000 g.p.d.
Total	430,000 g.p.d.

Over 3,000 ft. of water troughs were provided for horses and camels. Many elevated tanks and wells were built. Nine large convoys of camels carrying water in small tanks were provided, and a filling station with capacity for filling 2,000 camel tanks per hour was constructed. The advance from Beersheba called for facilities for nearly 500,000 U. S. g.p.d. At one time 2,000 men and horses with 48 hours of thirst arrived unexpectedly and were supplied.

These notes may be of some interest to the water works man as indicating some of the problems to be met in military operations.

MR. CLEARY. Adoption of precautionary measures depends in large degree on the type of the community. If there are no industries in the community there is very little likelihood that there will be any attempt to sabotage the water supply. But it is not too early to do effective thinking regarding possible emergency measures. For those communities along rivers, the matter of intake protection is very vital. That leads to the suggestion that sufficient intake pipe, or at least enough material to install an emergency intake, should be on hand.

Last May, when I made a survey of sabotage precautions I found only a few communities that had done any thinking about the matter. Since that time I know from various accounts that many communities have talked about precautionary measures and that in some places

actual plans have been carried out. One of our major industrial cities on the east coast, as far back as last October, discouraged visitors to all water works properties. This happened to be a very highly industrialized city. Further, to prevent the possibility of dropping dynamite into manholes leading to their underground water conduit, all manhole shafts were lowered to a depth of 5 or 6 feet. The ground then was filled in and sodded, so that any surface identification of a manhole was removed.

It would not be at all unwise to ban the public from water works properties and require that all visitors first report to the central office where their objectives and reasons for visiting may be carefully scrutinized.

The matter of providing guards is one on which we can refer to experiences during the last World War. Most places that tried this system did not find it entirely effective. It was said that in order to properly guard pipelines, it would be necessary to station men at about 25 ft. intervals, particularly in territories where these lines passed through uninhabited areas. Supply conduits are perhaps the most vulnerable structures in a water system and they are the most difficult to safeguard. In regard to the protection of dams the first step would be to curtail public fishing in reservoirs.

May I add one more thought, in connection with my visit to the Federal Bureau of Investigation, I spent one day with the General Intelligence Division of that bureau. The Army and Navy intelligence services, so far as activities concerning industrial production are concerned, have been transferred to the recently created General Intelligence unit of the F. B. I. The latter is interested in all kinds of sabotage. When I tried to get information concerning recommendations relative to water supply precautionary measures, I was told that nothing was available for publication. However, I was referred to Mr. J. Edgar Hoover, Director of the F. B. I., and he stated that a general information bulletin was being prepared. On the date when the bulletin was to be released I learned that the idea had been abandoned and that nothing would be made available.

The General Intelligence Division states that they have no power in affairs that do not concern interstate commerce. It was pointed out that many municipal water supplies might be considered interstate in nature, because they serve carriers passing across state boundaries, and in that case might fall under F. B. I. scrutiny.

The General Intelligence Division implied that any municipal water officer who is interested in getting information from the F. B. I. regarding protective measures might approach one of their local offices. They have, I believe, fifty-two field offices distributed throughout the country. The F. B. I. has prepared a manual of industrial plant protection measures, but this is a confidential document in the hands of F. B. I. officers. At the request of a plant where munitions or other war supplies are being made, the F. B. I. will make a survey and offer suggestions concerning what should be done to prevent sabotage. Perhaps this service could be extended to include municipal water works.

E. SHERMAN CHASE.* A New England community with an essential war industry has received instructions from the Navy Department to conceal the important gate boxes and valves controlling the major supply mains so as to preclude the possibility of intentional damage. Instructions have been received also to exclude visitors from the water purification plan.

Another point raised by Mr. Wiggin was with respect to the amount of damage being caused in the so-called noncombat areas abroad. As he said, we are getting almost no information as to what damage is being done to the water works in England. Last month I received two or three letters from English water engineers, but they gave little information in this respect. A letter from Mr. Cronin, Chief Engineer of the Metropolitan Water Board of London, written just about a month ago, says—and this is quite characteristic of the British temperament and the British morale—"It will be most interesting (referring to the new book on water purification, of the American Water Works Association) and all the more welcome as we hope to rebuild a number of our filtration plants after the war whether they get knocked down or not." How can you lick people like that? Referring to the question of damage he says: "So far only a few small pipes have been broken, but it is early days yet, and no doubt we shall get a great deal worse, but, then, it will be interesting to see if our preparations will enable us to deal with emergencies."

Now, to show that your Program Committee is not too much behind the times, I wish to say that we have written to Mr. Cronin

*Of Metcalf and Eddy, Consulting Engineers, Boston, Mass.

asking him to give us a paper after the war, upon what happened to his water works.

Although aerial bombing of American municipalities may seem a remote contingency, the precautions taken in Great Britain against war time damage to water works are worth recording.

The following notes constitute an abstract of a paper appearing in Water and Water Engineering (England) for 1940, this paper being entitled "A.R.P. (Air Raid Precautions) and Water Undertakings" by Granville Berry and Alan Boothman:

Mutual assistance between water works organizations is important. Such assistance should include interconnection of two or more adjacent water works systems, the loan of repair crews and the furnishing of spare equipment, sterilization apparatus, supplies and other resources in case of emergency.

Conservation of water sources, development of independent and alternate sources for fire fighting, provision for additional storage tanks, and the reconditioning of old mains to increase their conveying capacity, are advocated.

Hazard to dams, in the opinion of the authors, is likely to result from direct hits by bombs dropped from planes flying along the line of the dam. Such direct hits on earth dams might weaken the core walls or set up leaks with resultant erosion and possible failure. It is suggested that sand bags be available for repairing breaches and that rafts be constructed which can be floated to points of damage for closing such breaches as may occur.

Gate house controls might well be duplicated at the foot of embankments where danger of damage would be less than at exposed gate houses. Gate houses on distribution reservoirs should be protected against flying splinters, and bypass pipes around such reservoirs should be provided where possible.

Pumping stations and filter plants are difficult to protect against direct hits. They can be protected against splinters and incendiary bombs. Temporary standby pumping units in isolated locations will reduce danger of interruption of service and emergency chlorination equipment on filter plant bypass will preclude the pumping of dangerous water into the mains.

Elevated tanks and standpipes are difficult to hit but should be camouflaged to prevent their serving as landmarks for a hostile air force.

Aqueducts and trunk mains are not likely to be subject to direct attack, but should be provided with adequate control valves.

Distribution systems are likely to suffer the greatest damage. Valving off of damaged sections, and repair of broken mains, are of the utmost importance. These measures should be undertaken with the least possible delay by an organization trained and equipped to meet the emergency. Emergency repairs call for the use of flexible joints and bypass connections through fire hydrants. Many distribution systems should be provided with more valves. Dead ends should be eliminated and duplicate mains installed where needed.

Emergency chlorination equipment is essential in case of pollution incidental to physical damage from acts of war or from sabotage. Furthermore, parachute troops might attempt to pollute the water in distribution reservoirs subsequent to normal purification processes. Bleaching powder should be provided for disinfecting repaired water mains. Adequate reserve supplies of chlorine and bleaching powder should be kept on hand.

Temporary distribution of limited quantities of water for domestic needs may be provided by tank wagons.

Portable equipment for operating large valves, and providing compressed air and mobile pumping units are important.

Organization in control of water service must maintain closest coöperation with fire fighting and decontamination services. Methods to be used will depend upon size and extent of water system. Central headquarters with technical staff should be ready to deal with engineering problems and to coördinate the work.

Repair crews with tools and equipment should be available and in case of large systems these should be located in several sub-districts for immediate response to emergency calls. In some cases private plumbers should be on call. The personnel should have elementary training in anti-gas, incendiary bomb control, first aid and in working under abnormal conditions in protective clothing.

Consumers should be given instructions relative to the conservation of water. Household storage of small reserve stocks of water for emergency use is recommended. No water should be drawn at times of air raid warnings, except in case of dire necessity. Three pints of safe water per person should be kept on hand for drinking purposes. After an air attack water drawn from the taps should be

boiled before use for drinking and cooking until notice is given that the water is safe. Unnecessary telephoning to water works authorities should be avoided.

Sabotage comes in for very little discussion in this paper. Mention is made of the possibility of contamination of distribution reservoirs by parachute troops. Possibly sabotage by agents of hostile powers is less likely than in the United States.

NORMAN J. HOWARD.* I enjoyed listening to Colonel Longley's paper very much, chiefly because a little over twenty-five years ago it was through Colonel Longley that I came to America. Colonel Longley's firm had just finished the construction of a slow sand plant in Toronto and was looking for a man to come to help run it. He extended me the invitation to come. I lived with Colonel Longley, know him very well and had some very happy days with him. So it is a very great privilege and a pleasure for me to be able to attend these meetings from time to time, and renew acquaintances.

The question of sabotage did arise, some two years ago, following the Munich Conference. We were advised at that time from Ottawa, that the British Government had advised them of definite plans which had been outlined by the German government against all public utilities, including water, sewage, and hydroelectric plants. Immediately steps were taken and a plan was outlined for the protection of public utility plants throughout the Dominion. Fortunately the conference at that time reached what appeared to be a satisfactory termination, and plans were abandoned for any temporary protection, but nevertheless, when the war broke out about a year later the plans that had been prepared at that time were utilized and put into effect. They consisted of guards being established in all of the larger plants, the provision of barbed wire extending around the plants, flood lighting of all the essential points, and the exclusion of visitors except on a pass or permit. I well remember that when I was brought home from my vacation and tried to get into my own office, I had to go about two miles to the city to get a permit. That is how fast they worked.

After six months the guards in the city of Toronto had cost the city in the neighborhood of $180,000, and in that period in Toronto, as well as in many of the other cities in Canada, the secret service

*Director of Water Purification, Toronto, Ont.

had got a line on many persons who might be considered as potentially dangerous. As a result of that, certain people have been put in detention camps, and on account of the very great expense which was involved in the protection by guards, this service has been discontinued. The barbed wire is still maintained, visitors are excluded, and flood lighting is general around all of the big plants.

The British engineers at the outbreak of the war did definitely lay down plans for dealing with sabotage, and they stressed four or five different points that I believe are worthy of consideration. One consisted of the provision of emergency pumping equipment. In big cities of course that is a very big problem on account of the tremendous cost involved and of the difficulty in persuading many officials as to the necessity for such expenditures.

Reference was made to the distribution system, to provide additional valves that could be utilized at points of vantage and to place sets of plans of the system at various points on the distribution system. It was suggested that the city should be divided up, and the entire plans of the distribution system should be put at various points so that they could be easily reached should an emergency arise. One other condition which was emphasized was the value of cross-connecting adjacent services, so that if in one municipality the water supply failed, the water could be provided by a cross-connection to an adjacent municipality. I believe that is a very valuable thought to pass along where it is practical.

The provision of temporary equipment for disinfection of water also has been stressed, and that again I think is a very essential thing, because the cost is not prohibitive, and in the event of a main being disrupted, temporary equipment of that kind could overcome what might be a very serious problem.

Some reference was made here to the last World War. I visited in England about 1922, and I was at a plant there that did have four direct hits. They got a hit on the pumping station, on two of the filter beds, and on a 54-in. main that was under a pressure of 60 lb. per sq. in. It did do a very considerable amount of damage.

The Germans made several efforts to bomb the reservoirs in the east end of London. My advice, just a week ago, is that in this war there have been two or three very large mains directly hit within the past few weeks. I received a letter about a week ago that took about

seventeen days to come, and at that time there had been one or two of the very large mains hit in the city of London.

FRANK E. HALE.* Regarding the use of poison gases in warfare, the most dangerous effect would be a bomb of mustard gas landing in a reservoir. Mustard gas will hydrolize in one or two days, and that will correct the condition, or it may be destroyed by a high dose of chlorine, which shows the importance of having chlorination facilities. I do not think that bacterial pollution was practiced in the last war and I should not think that it would be in this one, but if it were, again chlorination is very important because the ordinary disease bacteria carried by water would be controlled by chlorination, that is, typhoid, dysentery, Asiatic cholera. All but amoebic dysentery would be handled by normal chlorination.

Very helpful is a pamphlet published in London entitled "The Detection and Identification of War Gases." If copies are still available they may be obtained from the British Library of Information, 50 Rockefeller Plaza, N. Y., for thirty cents. The following paragraph on page 5 of this pamphlet is particularly interesting.

"Most of the gases are relatively insoluble in water: some, such as chloropicrin, are practically unaffected by it: others, like mustard gas, are slowly hydrolyzed: while still others, for example, phosgene and lewisite, are rapidly decomposed. Evidently, therefore, in rainy weather the latter will be relatively ineffective, and the persistence of mustard gas will be considerably reduced, quite apart from any mechanical washing away that may occur."

FRANCIS H. KINGSBURY.† Colonel Longley went into the question from the standpoint of the large supply.. This problem of the army, the preparation for service of a water supply, could well be carried clear down to the company; perhaps not with elaborate equipment but certainly in education. Having had training in sanitation in water supply, and also in the other ways of health of the company personnel, I took a little justifiable pride in the fact that 250 men of ordinary intelligence could, after the matter had been explained, appreciate the importance of not drinking water that had not been protected. Day after day on the march, my company would go right along passing 30 or 40 men from other companies out in the field with diarrhea.

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Disinfecting the canteen full of water seems to me to have a good deal of merit, especially when you are moving quickly from one place to another. We had a great many complaints from the soldiers over the shoe leather beefsteaks, but the cooks were told to cook it thoroughly all the way through to avoid any ptomaine poisoning. If it is worth while to do that with food, it is worth while to protect water supply. We had our gas defense schools and other special army schools. I offer the suggestion to anybody who has control over army matters, that it might be worth while, even though expensive equipment is not afforded the company, to detail a sergeant or two from time to time to a water works school.

A. E. GRIFFIN.* The standard Lyster bag used by the U. S. Army holds 36 gal. of water. Sterilization is usually accomplished by the addition of the contents of one or more hypochlorite capsules, each of which, according to the directions thereon, is sufficient for one Lyster bag (30-35 gal.). Such a procedure, of course, is not entirely satisfactory since it leads either to under-dosing with consequent inefficient sterilization or to overdosing with the production of tastes to the point where the water becomes unusable.

To overcome these objections, it is suggested that over-doses of hypochlorite be added followed, after a definite time interval, by the addition of a dechlorinating agent such as sodium thiosulphate or sodium bisulphite. It is felt that the use of sodium thiosulphate would be more practical since it is usually obtainable at drug stores.

The amount of hypochlorite per capsule appears to vary since capsules are usually made up according to specification. In any case it appears that the intent is that they shall contain enough 70% hypochlorite to give a dosage of at least 1.0 p.p.m. This in itself would lead to a variation in the residuals produced since it is inevitable that different waters will absorb different quantities of chlorine. It would appear very practical then to add sufficient chlorine to produce a chlorinous taste and then to remove this taste by the addition of the contents (0.2 grains $\pm$) of one or more capsules of thiosulphate.

The health authorities of the Boy Scouts of America advocate that all drinking water used by Scouts in camp shall be sterilized by the addition of iodine or Halazone tablets. The claim is that these

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are available in all drug stores. Experience indicates, however, that not all drug stores carry these tablets and that they are only obtainable in the larger ones.

In conclusion it appears that safe drinking water should be obtainable in the field by chlorinating to the point where tastes and odors of chlorine become very noticeable, followed by dechlorination with thiosulphate to the point where the water becomes drinkable. Where obtainable, iodine or Halazone tablets have been used. In any case there seems to be real need for a standardized procedure.

H. S. HUTTON.* Through our associate company, Wallace & Tiernan of London, we do get some reports from London. For instance, it is our understanding that every water supply in England has been ordered to provide adequate chlorination equipment. Just in the last month I venture to say that twenty-five installations were made on the London water supply.

Another thing that is interesting to note is that the camps, apparently the army camps, are installing temporary equipment, while the city supplies are installing permanent equipment of standard design.

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FOUR DISASTERS

BY H. T. GIDLEY*

[*Read September 27, 1940.*]

The Fairhaven Water Company was incorporated in 1888. For several years after the incorporation of the company not much progress was made, but finally Mr. M. M. Tidd, Engineer, drew up plans for the system. Meanwhile, Mr. Henry H. Rogers had incorporated a public library. He then bought out the stock of the Water Company, and turned it over to the Millicent Library. Up to the present time, the Millicent Library holds all the stock of the Water Company except six shares that stand in the names of Directors for management only.

The original plant consisted of a pumping station and driven wells. In this station were two steam pumps of 1,000-g.p.m.

First Disaster. The distribution system included an elevated tank holding 383,000 gal. which was 50 ft. high on legs 100 ft. long, giving it an elevation 193.4 ft. above mean sea level. The bottom of this tank was made in the form of an inverted cone. This was done to avoid cross beams. The bottom plates were placed in circular rings with radial joints, and the seams were lapped and double riveted. The radial seams with butt joints and single collar plates were also double riveted. Twelve posts in a circle under a collar supported the tank. These facts were taken from an article written for the NEW ENGLAND WATER WORKS JOURNAL by Joseph K. Nye in 1894. In the discussion of this article at a New England Water Works Meeting, Mr. Tidd said: "This standpipe was constructed of iron, and I have always preferred iron to steel from the fact I had rather have the best quality iron than the very poorest quality steel. I have noticed that all the standpipes in the country that have fallen have been of steel, while I know of no instance of an iron one falling." Nevertheless, this standpipe collapsed on November 9, 1901, at 4 p.m. on a pleasant afternoon with no wind blowing. The seams in the conical bottom opened up, and the water rushed out with a horizontal rotary component of motion. As a result the tank revolved about its axis

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more than half way, and the legs kicked the two 2-ton blocks they were set on out into the lot nearby.

Second Disaster. In 1925, our combined office and works were located at 6 Bridge Street. Right back of us was a large boat shop three stories high, which towered above our one-story building. On October 23, 1925, late at night, a fire broke out in the boat shop. The alarm was rung in quickly, and the fire apparatus was soon at hand, but the fire spread so rapidly that there was no time to remove anything from our building. The heat was intense; it melted the enamel off wash basins, and burnt off the sides of meters. The building was a total loss, but we were fortunate in having a fireproof safe. The combination was burnt off, and the door hinges had to be cut off to open the safe, but all the contents were found intact.

This building was replaced in 1926 with a much better equipped brick building. We were fortunate that the paint shop was removed from that locality. There was therefore much more light, air, and view than before.

Third Disaster. On September 28, 1933, lightning struck the chimney of our Mill Road pumping station. The outer wall was pretty well demolished, but the core was left in a very pecarious position. It seemed as if the lightning on striking between the outer and inner walls perhaps exploded the gases between them, as the bricks seemed to fall equally in all four directions. The core left standing had to be removed, but the station on one side and large trees nearby prevented it from being felled. A local contractor said he would build up a staging around the core, and this staging of course could be used in building a new chimney. This was done, but the carpenters on the job were not easy until it was successfully accomplished.

Fourth Disaster. The three major events in this article as you see, are the collapse of the standpipe, the burning of the office and workshop, and the destruction of the chimney by lightning. There might be added the fact that in the hurricane of 1938 the water rose in our office nearly four inches and that there were small fish in the basement on the next morning. The water entered only one pumping station however. Here the water was three feet deep, but it only kept us from pumping during two days.

FILTER OPERATION AND MAINTENANCE

BY JOHN R. BAYLIS*

[*Read September 26, 1940*]

The operation and maintenance of the filters in a water treatment and filtration plant is an important part of the duties involved in running the plant. The method of operation varies considerably and depends more upon the ideas of the person in charge of the plant than on some definite standard of operating procedure such as is used in making laboratory tests. If the operator chooses to wash filters at a loss of head of 5 ft., he does so, and frequently without any good reason other than his belief that it is better to wash at that loss of head. Another operator may choose to allow his filters to continue in service until the loss of head increases to 9 or 10 ft., although coagulated matter may at times pass through the filters at such a high loss of head.

The filters in one plant may be washed for 3 minutes; in another plant with the same conditions and character of water, they may be washed for 5 minutes; and in a few plants they are washed for 8 to 10 minutes. The backwash valve is opened quickly in some plants, and slowly in others. The condition of the filter beds may be watched closely or almost ignored. Complete records of the filters are kept by some; others make record only of the time when the filters are washed. Filters are operated at a constant rate in some plants, cutting off or turning on units to vary the rate; in other plants all of the filters are kept in operation, and the rate is varied to meet the fluctuating demand.

The remark often is made that no two filtration plants are operated alike. Perhaps no two should be operated exactly alike, though it does not seem that there should be such wide variation in manner of operation as now exists. There is no standard of operating procedure; yet it seems evident that a standard of procedure with reasonable provisions for modifications to meet local conditions would bring about better filter operation in many places. Also there is no

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standard of filter condition at which to aim in maintaining the filters such as we have for bacteriological requirements or clarity of the filtered water. There is not very much in the literature to tell operators what constitutes good practice in the operation and care of filters, and not much to tell them what constitutes poor operation. Lack of more uniform operating procedure likely is responsible for some of the lack of interest in the filters. So long as they function reasonably well they often are given little thought.

Filters Neglected. In the early stages of rapid sand filtration, considerable attention was given to the filters, and they were expected to be highly efficient, although methods of measuring the efficiency at that time would now be considered crude in some respects. The filters were regarded as the most important part of the plant and were treated with care commensurate with their importance. The ability to produce good coagulation by chemical treatment, combined with sedimentation, now removes so much of the suspended matter in the water in many filtration plants before it goes to filters that not much is left for the filters to remove.

Chlorination has obviated the necessity of trying to produce a certain bacterial efficiency in the filters themselves. Many operators now believe that there is no need to maintain the filter beds in perfect condition; as a result, the beds in many plants are allowed to get into horrible condition. Filter beds have been observed to be so badly clogged and ridged at the surface that it does not seem possible that the filter could properly remove even the little amount of suspended matter left in the coagulated and settled water. This has strengthened the belief of operators that the condition of the filter bed has little influence upon its efficiency.

There has persisted from the beginning of filtration the belief that gelatinous, coated sand grains filter better than clean grains, and it is only within the last few years that this assumption has been questioned.

Ignoring the condition of filter beds frequently results in the filters not doing as much as they should in producing the highest quality of water attainable. *It is far better to have less sand-grain coating and cleaner beds, than to have well coated sand and filter beds filled with mud balls and clogged areas.* Accompanying dirty and clogged filters, there almost invariably are cracks, pulling away of the beds from the sidewalls, and ridged or mounded gravel.

The purpose of this paper is to discuss the duties involved in the routine operation of filters and the care that should be given them in order to maintain the beds in good condition. The paper is divided into two parts: the first pertains to the duties of filter operators in running the filters, and the second relates to maintenance of the filters. Under maintenance is included discussion of some of the filter bed troubles not included in a previous paper.[1]

Filter Operation

Good filter operation has much to do with the effectiveness of filters in performing their function properly. Written instructions for the guidance of those operating filters are advisable in any plant in which more than one person is employed as an operator. All plants operating for 24 hours daily will need at least two shifts of operators, and in most localities three shifts are required. With allowance for one day off in each week, the services of four persons are required in the operation of the average, small, one-man plant. Although one of the operators may be responsible for operation, he cannot be on duty all of the time. The instructions may be short and not go much into detail, or they may be in such detail that there can be little question as to their meaning.

Considerations of Greatest Importance. There are two considerations in the operation of a water purification plant of which we cannot say that one is more important than the other: sufficient water must be filtered for the needs of the city, and the water must be safe. All filtration plants should be adequate to meet fully these two requirements; if not, the management of the plant should have such improvements made as are necessary. In addition to the two main requirements, the water should be clear, pleasing to the taste, free from excessive hardness, and not corrosive to the distribution mains. The efficient operation of the filters may not be of major importance in producing these essential or desirable features, yet it will influence the production of water of high quality.

Average Filter Assumed. The suggestions that will be offered for operation of filters apply to typical rapid sand filters. Each filter will be assumed to be equipped with a rate controller, loss of head gauge, filtration rate gauge, and hydraulic valves operated from a filter operating table. Most filters are so equipped. In addition it will be as-

[1]Baylis, John R.: Filter Bed Troubles and Their Elimination. This Journal, 51, 36 (1937).

sumed that there are mixing and sedimentation sufficient to produce good conditioning of the water and that there is a clear water reservoir of sufficient capacity to supply the demand for water for several hours.

First Duties of Operators. The operator going on duty should inquire from the operator going off duty if there is anything unusual that may require special attention. The operator going off duty should, without being requested, report anything needing the attention of the next shift. Even when he has received a favorable report, each operator in starting his work should examine all parts of the plant over which his duties extend. Since this is a discussion of filter operation, the duties mentioned will be confined to those relating to the operation of the filters. If everything appears to be operating satisfactorily, the operator may proceed with his routine duties.

Rate of Flow. Except in plants in which the filtered-water storage exceeds several hours of draft, the hourly fluctuation in water consumption is at least partially taken care of by varying the rate of filtration or the number of filters in service. In order to avoid frequent changes in the rate of flow through the plant, operators should study carefully the consumption characteristics of the city. When consumption begins to increase in the morning, both the settling basins and the filtered-water reservoir may begin to be drawn down. If the filters increase and decrease their rate of operation automatically, as they do in some plants, the water level will be lowered in both reservoirs but will drop in the clear-water basin only enough to produce a rate of filtration equal to the rate of discharge from the plant. The flow-line of the filters, however, will continue to drop until the flow through the plant is increased.

The water level above the filter beds is usually allowed to sink to some definite elevation before the rate of pumpage is increased. A knowledge of consumption characteristics enables the operator to predict the rate that should be set. Automatic control of the flow of water into mixing and settling basins in accordance with the rate of filtration has not proved practical. The rate of raw-water flow, when consumption is increasing, should be raised higher than the coincident rate of discharge into the distribution system in order to increase the water level in the settling basins. When estimated closely, the level will nearly reach its maximum height before the increased consumption in the city equals the flow through the plant. Although there is wide

fluctuation in the consumption of water throughout the day, many plants are being operated with only a few changes in rate during the day.

TABLE 1.—RATE OF FILTRATION AND LOW-LIFT PUMPAGE.

Area of water surface in settling basins and on filters = 67,000 sq. ft.

Hour	Rate of Filtration m.g.d.	Rate of Filtration m.g. per hr.	Water Filtered during Past Hour, m.g.	Rate of Low-lift Pumping m.g.d.	Excess or Deficiency of Water, m.g.	Variation in Water Level on Filters,† ft.
12	20.0	0.833		20.0		
1 a.m.	18.8	0.784	0.809	20.0	+0.024	+0.05
2	18.5	0.772	0.778	20.0	+0.079	+0.16
3	18.5	0.772	0.772	20.0	+0.140	+0.28
4	18.4	0.767	0.770	20.0	+0.203	+0.41
5	18.5	0.772	0.770	20.0	+0.266	+0.53
6	22.5	0.938	0.855	20.0	+0.244	+0.49
7	27.0	1.125	1.032	20.0	+0.045	+0.09
8	33.0	1.375	1.250	*29.0	+0.003	+0.01
9	35.4	1.475	1.425	29.0	—0.214	—0.43
10	37.8	1.575	1.525	*38.0	—0.156	—0.31
11	38.0	1.583	1.579	38.0	—0.152	—0.30
12	37.8	1.575	1.579	38.0	—0.148	—0.30
1 p.m.	37.0	1.542	1.558	38.0	—0.123	—0.25
2	36.5	1.521	1.531	38.0	—0.071	—0.14
3	36.4	1.517	1.519	38.0	—0.007	—0.01
4	35.6	1.483	1.500	38.0	+0.076	+0.15
5	37.0	1.542	1.513	38.0	+0.146	+0.29
6	38.8	1.617	1.580	38.0	+0.149	+0.30
7	40.6	1.692	1.654	38.0	+0.078	+0.16
8	39.4	1.642	1.667	38.0	—0.006	—0.01
9	34.0	1.417	1.530	38.0	+0.047	+0.09
10	30.2	1.258	1.338	*29.0	+0.011	+0.02
11	23.9	0.996	1.127	29.0	+0.092	+0.18
12	20.4	0.850	0.923	*20.0	+0.002	0.00
Total water filtered			30.584 m.g.			

*Pumping rate changed at 7 a.m., 9 a.m., 9:15 p.m. and 11 p.m.
†The zero elevation is assumed to be the average water level on the filters.

The values listed in Table 1 are characteristic of the fluctuations in rates of filtration in a typical city using about 30 m.g.d. of water. The table includes only the variation in water filtered and does not take into consideration the variation in the water level of the clear-water reservoir. In plants that are automatically controlled, a fluctua-

tion of one to two feet in the level of the clear-water reservoir usually is sufficient to produce variations in plant output equal to those in consumption. The table shows that the low-lift pumpage in this assumed case would have needed to be changed only four times during the day if the rate of filtration could have been predicted accurately. In actual practice the pumpage probably would have to be changed five or six times during the 24-hour period. This is because the rate of consumption cannot be predicted accurately.

In large plants, in which several employees are required on each shift, the responsibility for maintaining an adequate water level in the basins or reservoirs probably should be entrusted to the person operating the filters. He should notify the operator of the low-lift pumps, if the water is pumped, and also the chemical operator of the rate of pumpage desired so that changes in pumpage and quantities of chemicals being applied may be made simultaneously. Where water is withdrawn from a storage reservoir and does not have to be pumped, the chemical operator usually opens and closes the gates to maintain the desired rate, though the filter operator should be the person to state the rate at which the flow should be set.

Reference is made to filter operators, pumping station operators, and chemical operators. In small plants, the duties of all of these may be performed by one person; and in larger plants, by two or more persons.

Water Levels. Experience determines the allowable fluctuations in water levels in the various reservoirs within the plant and also the fluctuations that may be expected to take place under conditions of ordinary operation. In general, it is good practice to maintain all reservoirs nearly full of water all of the time. There are two reasons for maintaining the flow line of settling basins nearly at maximum elevation: one is that the mixing and settling period is kept long owing to the increased depth of water; the other is that with the reservoir nearly full, interruptions in flow for a few minutes will not require shutting down the filters. Where the only consideration for maximum elevation is the danger of overflowing the basins or filters, it is good operating practice to attempt to maintain a free board of 6 in. to 12 in. below the top of the filter walls with a minimum value of about 3 in. and a maximum of about 15 in. Instead of the filter wall, the height of the settling basin wall, or of some overflow, may determine the maximum flow line.

If the water level on the filters is falling, it may be allowed to sink about 12 in. below the maximum elevation before the rate of flow is increased, unless a knowledge of consumption characteristics indicates that the change should be made before the water level has dropped to the level set for the minimum. An examination of Table 1 shows that the change in rate may need to be made when the water level is near the average level. After increasing the rate of flow, it usually should not be reduced until the water level has increased at least to the average level, and in most instances preferably to near the maximum elevation, unless consumption characteristics indicate differently. No rule can be strictly followed. Wider fluctuations in water elevations than those mentioned may be used in some plants, while in others smaller fluctuations may be desirable.

The water level in the filtered-water reservoir may be allowed to fluctuate considerably, although, unless the plant is loaded to capacity, most operators prefer to keep this basin nearly full all the time. This is good practice, for should there be some cause for shutting down the plant, or a break in a large main which greatly increases the draft, there is a reserve supply to meet the needs. Engineers may calculate the economics of drawing down the clear-water reservoir to meet peak consumption and this may be all right for distribution reservoirs or very large reservoirs, yet no operator is going to lessen storage greatly at the plant unless the filters cannot supply more water. The writer, in the operation of filtration plants, has endeavored always to maintain the clear water reservoir as nearly full as practical. Others follow this same practice and will continue to do so regardless of what may be considered most economical.

Watch for Improperly Conditioned Water. Although the filter operator in a large plant may not be responsible for the application of the chemicals to the water, he is in a better position in the plant than any one else to watch for improperly treated water. When the water does not appear to have been properly treated, he should immediately report this to the person responsible for chemical dosage. There is usually some place in the plant at which the water leaving the settling basins to go to the filters can be observed and changes in the appearance of the water indicative of improper treatment can be detected. Sometimes this is done by noting the clearness with which the wash-water troughs in the filters are seen. Lights may be used to enable the operator to detect deviations in the clarity of the settled

water; or, the water may be sampled and tested for turbidity. Turbidity tests are not used, however, by many filter operators.

The best criterion of the adequacy of treatment is the clarity of the filtered water. All filtration plants, regardless of capacity, should have some means of making the necessary observation quickly and conveniently. There is no better means than a light submerged in 8 to 12 ft. of the filtered water, somewhat as shown in Figure 1. A

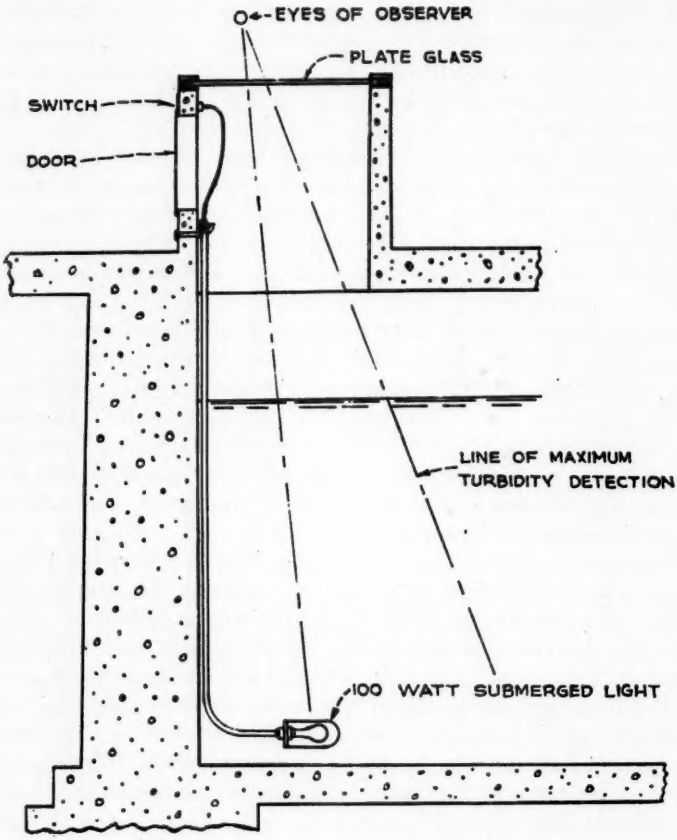

FIG. 1.—SUBMERGED LIGHT FOR THE DETECTION OF TURBIDITY.

turbidity of 0.1 p.p.m. in the water is detectable, and higher turbidities are readily noticed with the light.

Washing Filters. The loss of head at which filters are washed varies in different plants. In many places, operators wash at a loss of head of 8 to 9 ft. The practice most generally followed is to allow filters to run until the loss of head increases to the maximum and the rate begins to decrease, though there are a number of plants where it has been found best to wash at a head loss less than the maximum head available.

In some plants, coagulation may become so weak at times that coagulated matter will pass through the filter before the loss of head reaches the maximum value used in the ordinary operation of the plant. Such filters should be equipped with floc detectors. The operators should then watch the water in the floc detectors and wash the filters when coagulated matter begins to pass through them, regardless of the loss of head. Where floc detectors are not installed, good practice is to assign to the time of service between washes some maximum value that is believed to insure that no coagulated matter will pass the filters.

The procedure that the author will recommend for washing filters is believed good practice. It assumes that the filters are equipped with surface-washing systems. Many filters are not so equipped, however. For these, the procedure given for washing will be the same, except that the steps relating to surface wash must be omitted. In addition the backwashing rate is generally the same throughout the wash.

Procedure for Washing Filters Equipped with Surface Washes

1. Just before cutting off a filter to be washed, record in a note book, or on a form provided for filter records, the rate of flow and loss of head. Although the filters may be equipped with recording gauges, this record should be made.
2. Close the influent valve and make record of the hour and minute when closed.
3. Allow the level of the water on the filter to lower by continuing the filter in service until the level of the water is only about 4 to 6 in. above the top of the sand.
4. Close the filter effluent valve and make record of the time closed.

5. Inspect the filter bed for cracks, mud balls, pulling away from the sidewalls, or any other unnatural condition. Make record of the inspection. A close inspection of the bed each time a filter is washed need not be made, though inspections should be frequent enough to have a good record of the condition of the beds.

6. Open the drain valve. This may be done after the water level has been lowered below the top of the wash-water troughs, but must be done before the wash-water valve is opened.

7. Open the surface-wash valve.

8. Open the backwash valve at a rate that will require at least 30 seconds to elapse before a backwash rate of about 10 g.p.m. per sq. ft. is established. If surface wash is not used and the rate of backwash is about 15 to 20 g.p.m. per sq. ft., the time required for opening the valves should be increased to about 45 seconds. (The low rate of backwash should expand the bed 10 to 15 per cent. Use a rate that will give this expansion.)

9. After the backwash valve has been opened to give the desired backwash rate, allow the washing to continue for the time designated in the instructions, or the time essential for good washing.

10. One-half to one minute before the end of the wash, increase the backwash rate to the maximum rate desired.

11. Close the surface-wash valve just before starting to close the backwash valve. (Where lengths of filter run are short they may be increased to some extent by cutting off the surface wash after the backwash.)

12. At the end of the designated washing period, start closing the backwash valve. The rate of closing may be more rapid than the rate of opening, but it should not be rapid enough to create water hammer in the wash-water piping.

13. Close the drain valve.

14. Open the influent valve sufficiently to allow the water to flow into the filter about as rapidly as it would when the filter is operating at full capacity. The valve will be about one-fifth to one-fourth open. Allow the water level on the filter to rise to at least 6 in. above the level of the wash-water troughs before increasing the valve opening.

15. Turning on the influent water too rapidly at first may cause the sand in the filters to become ridged on the surface. If the operator has nothing else to do he may remain at the filter and keep opening

the influent valve at intervals of one or two minutes so as to maintain as rapid a rate of flow as possible without disturbing the sand surface.

16. When the level of the water on the filter is approximately that of the other filters, open the influent wide, then start opening the effluent valve. Most filters are equipped with rate controllers that quickly come into play, and there usually is not much danger in opening the effluent valve rapidly. If the controller is such as to allow a very rapid initial flow before the control mechanism checks the rate, the effluent valve should be opened slowly at first, until it is evident the controller will regulate the rate.

17. Record the time when the filter is placed back in service.

Local conditions will cause modifications of the method of washing filters. In some plants the backwash is turned on in advance of the surface wash. Occasionally the rate of opening the backwash valve is slower than the rate recommended. There is no objection to opening the valve more slowly, but to open it rapidly may damage the filter bed, because the bed will not expand rapidly. The suggestions given apply to filters not equipped with auxiliary aids to washing other than a surface-washing system. Where air is used and is forced through the filter underdrains, prevailing practice is to blow air through the filter bed for an interval of three to eight minutes before turning on the wash water. Where there is a separate system of air and water, the two may be used at the same time, though the backwash rate must be low while the air is turned on if loss of sand is to be avoided.

Record of Wash. The filter operator should have a stop watch, or there should be an electric clock with second hand large enough to be observed from each filter in the plant. Although it is not customary to make a complete record of the opening of the wash-water valves, the author is of the opinion that such records should be kept. The record should include the number of seconds required to open the wash-water valve to its initial rate (assuming a surface-washing system is installed), the minutes and seconds operated at this opening, the time required to open to the maximum backwash rate, the time washed at the maximum rate, and the time required to close the valve. Perhaps this will be regarded by some as a useless record; yet if kept it will insure more uniform filter washing.

The wash-water line in some plants is provided with a meter for measuring the amount of wash water used; in others, the amount is

computed from the time and rate of wash. In a few plants the drain valve is closed in advance of the wash-water valve so as to allow the water to partially fill the filter above the troughs with wash water. It probably makes little difference which procedure is followed, but it would seem slightly more expensive to fill the filter with wash water than with settled water.

Filter Bed Expansion Rate. When water is made to flow upward through a bed of sand at a rate that will expand the bed about 50 per cent, the time required to expand fully the material is greater than a few seconds. The curves in Figure 2 show the time required

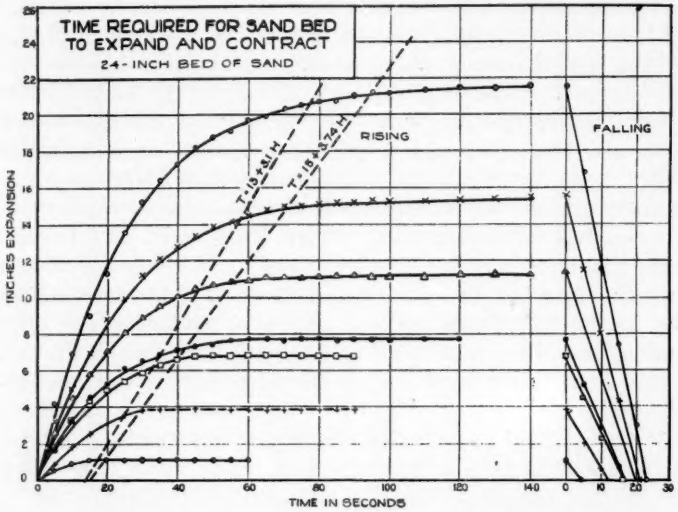

FIG. 2.—TIME REQUIRED FOR A 24-IN. SAND BED TO EXPAND DURING WASHING.

to expand a 24-in. bed of sand to various heights over its original depth. The backwash was turned on very rapidly. When this is done, the filter bed rises as a mass and the sand starts expanding at the bottom. Soon the bed is largely floating on a layer of expanded material somewhat as is shown in Figure 3. Before the bed becomes expanded to its surface, there will be breaks through the unexpanded portion as shown in the illustration, and this will allow water and sand to rush through the hole rapidly. The specific gravity of the un-

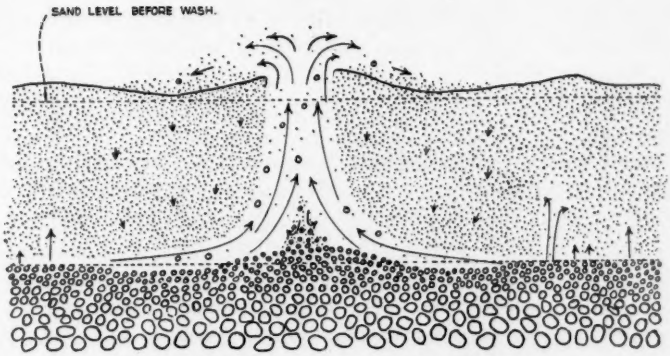

FIG. 3.—SAND BOIL AT THE START OF WASHING.

expanded portion is greater than that of the expanded portion near the gravel, and this causes the water and sand to travel across the surface of the gravel towards the boil at a velocity that will disturb the gravel and cause some of it to become mounded under the boil. If the practice of turning on the backwash rapidly is continued, it may produce serious displacement of the gravel.

The time required to expand the sand bed fully, as shown in Figure 2, is given closely by the equation

$$T = 15 + 3.74\ H$$

where T = Time in seconds for bed to expand
and H = Expansion of the bed in inches when fully expanded for the particular rate of backwash.

The size and specific gravity of filtering material, and the size of the filtering units influence the rate of expansion. In large filters, it is impossible to turn on the wash water suddenly. The valves generally are set to open slowly, and this is as it should be. There is some evidence that the time of opening the backwash valve to give a certain expansion of the bed should be about the same as that required to almost fully expand the bed.

Filters Out of Service. In plants having less than 10 filter units, not more than one filter should be cut off at one time for washing, unless the filter capacity greatly exceeds the plant output. Where the number is between 10 and 40, it may be necessary at times to have two filters out of service simultaneously for washing. It is

good practice to confine coincident washing to as few filters as possible. All of the filters should be kept in service all the time, though this is not practical without automatic rate control. Filters cut off more than several hours should be washed just before being placed in service.

Other Duties that Should be Performed at Time of Washing a Filter. Practice varies in the care given to filter beds other than that required in their routine operation. Where filters are not equipped with surface-washing systems the water is sometimes drawn below the sand level at frequent or occasional intervals and a hose used for breaking up mud balls and other accumulations of mud at the bed surface. Some operators report that they are able to keep mud balls broken up fairly well by this procedure. A ¾-in., or 1-in. hose connection with a short piece of hose and a nozzle is used extensively for this purpose.

The operator is expected to use the hose whenever there is floating material on the water, such as foam, which is not washed away by the backwashing. Also he is expected to wash the sidewalls of the filter to prevent accumulation of mud on the walls above the sand level. Hose connections therefore, are advisable for all filters. Hosing the sidewalls of filters is not a burden upon operators and should be regarded as part of their duties. In large plants, where many filters have to be washed, a laborer may be employed for the hosing. Keeping the sidewalls of the filters clean may have nothing to do with the efficiency of the filter, yet it gives the filters a neater appearance.

Length of Filter Wash. No definite time can be set as the most desirable length of filter wash. Where a considerable amount of coagulated material has been removed by the bed, the washing period should be extended. Table 2 gives what are believed to be values in good practice, although they should not be followed everywhere. In some places this length of wash may not be sufficient; in other places it may be more than enough.

The washing times given in Table 2 hold for settled water that possesses a turbidity between 2 and 5 p.p.m. When the turbidity lies between 5 and 10 p.p.m., one-half minute should be added to both the backwash and the surface-wash times. Where the turbidity of the settled water is over 10 p.p.m., a still longer period of washing may be desirable. The added time applies to the low-rate backwash and not to the highest rate.

TABLE 2.—LENGTH OF FILTER WASH.

The time given does not include time required to open and close the wash-water valve, but does include the time needed for increasing from the low to the high rate.

Filter run, hours.	Time of Backwashing, minutes		Total Time of Backwashing, minutes	Time Surface-wash Valve Open, minutes
	8- to 10-gal. rate*	15- to 20-gal. rate*		
4	1.5	0.5	2.0	2.0
6	1.5	0.5	2.0	2.0
8	1.5	0.5	2.0	2.0
10	2.0	0.75	2.75	2.75
12	2.0	0.75	2.75	2.75
16	2.0	0.75	2.75	2.75
18	2.0	0.75	2.75	2.75
20	2.5	1.0	3.5	3.5
24	2.5	1.0	3.5	3.5
28	2.5	1.0	3.5	3.5
32	2.5	1.0	3.5	3.5
36	3.0	1.0	4.0	4.0
40	3.0	1.0	4.0	4.0
50	3.0	1.0	4.0	4.0
60	3.5	1.0	4.5	4.5

*Rate in g.p.m. per sq. ft.

Where a surface-washing system is not used, filters should be backwashed at the maximum rate for the time given in the column marked "total time of backwashing", if the rate is about 15 g.p.m. per sq. ft. For a backwash rate of over 20 g.p.m. per sq. ft. without a surface washing system, the time given in the column headed "8- to 10-gal. rate" would result in a very good wash.

Washing until the wash water possesses a certain turbidity may be good practice, but it is difficult to know when the water has reached the desired value. Figure 4 gives the turbidity of the wash water for a typical wash. Occasional collection of samples of wash water and determination of their turbidity would enable the operator to establish the length of wash more intelligently.

Bumping Filters. When filter runs are short, it is frequently difficult to wash the filters as rapidly as they reach their maximum loss of head. Sometimes, filter operators resort to breaking the surface layer of the filter by turning on the wash water for a brief time. This reverse-flow agitation is often referred to as "bumping". To bump a

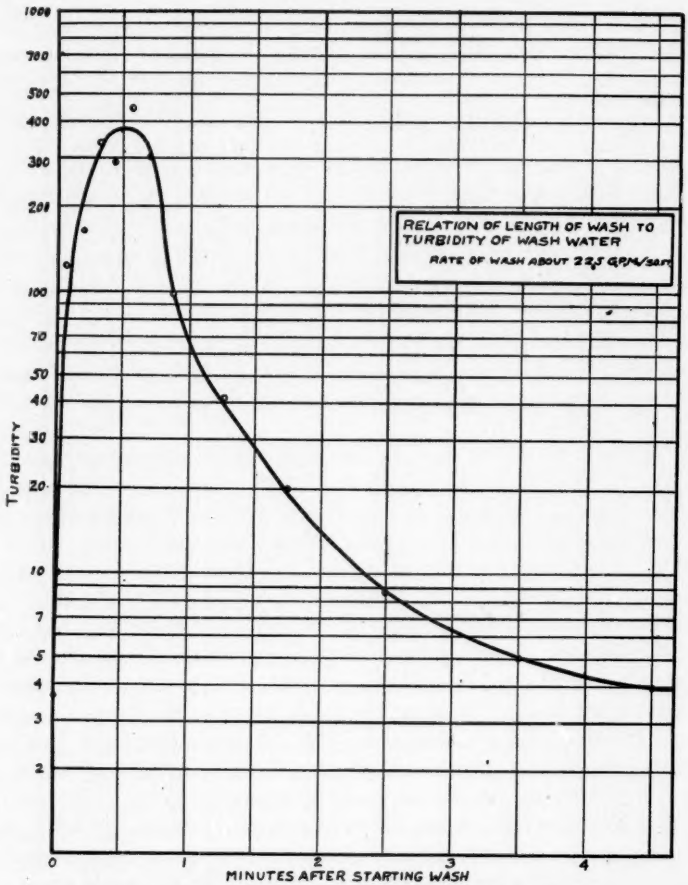

FIG. 4.—LENGTH OF WASH AND TURBIDITY OF WASH WATER.

filter close only the effluent valve, turn on the backwash for about five to ten seconds at a rate just sufficient to break the surface of the bed in numerous places, then cut off the backwash. The filter may then be placed back in service. The total time required to do this is usually not more than two to three minutes. Figure 5 shows the fresh sand surface produced by bumping the filter.

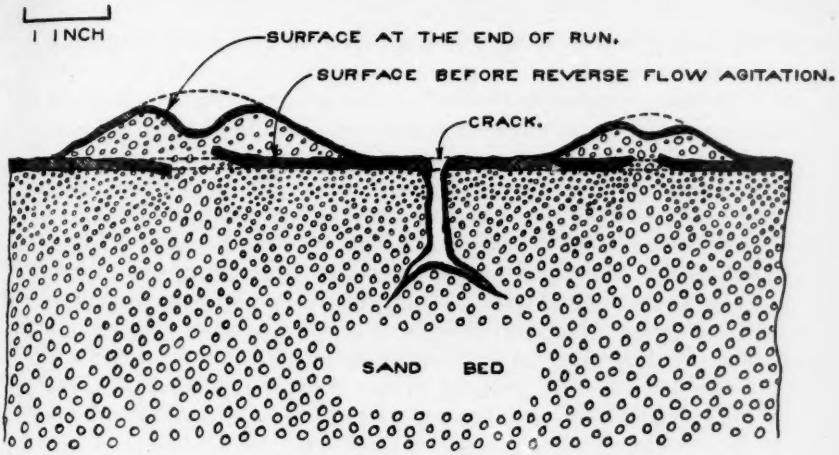

FIG. 5.—CRACKS AND MOUNDS PRODUCED BY REVERSE FLOW AGITATION OR "BUMPING".

Bumping should not be resorted to unless filter runs are so short that it is not possible to wash the filters as rapidly as they reach their maximum loss of head. No definite minimum length of run can be set. In large plants, it may be difficult to operate with runs shorter than 12 hours, whereas in small plants there may be no difficulty in operating with 6-hour runs.

MAINTENANCE OF FILTERS

The maintenance of filters includes consideration of filter-bed troubles and methods of preventing or eliminating such troubles. "Filter Bed Troubles and Their Elimination" was the subject of a paper published by the author in the March, 1937, issue of this JOURNAL. The discussion given here is intended to be a supplement to the former paper, and does not include reference to some of the major filter bed troubles previously discussed. The former paper covered formation of mud balls and clogged areas in filter beds; cause of beds pulling away from the sidewalls of filters; cause of cracks in the surface of filter beds; jet action at the sand-gravel junction; effect of jet action on mounding of the gravel in filters; and methods of cleaning dirty filters. The paper also discussed a method of measuring the volume of mud balls in filters, the grading of the filter-bed material

at the sand-gravel junction, and the use of surface-washing systems to aid filter washing.

Improved Operation Desirable. Fortunately there is now sufficient realization by operators that filter beds should be kept in better condition than in the past, and much progress has been made towards better maintenance of filters. We may expect the effort to continue until there is scarcely a poorly maintained filter in the country. Keeping the filters in good condition is not going to be the solution of all operating difficulties, however, for proper conditioning of the applied water and other precautions are also essential; yet improving filter performance will be of considerable help in reducing of some of the troubles experienced in so many filtration plants.

There has been a tendency within the past few years to speed up the rate of filtration and to use coarser sand. As a result, we are in some instances approaching too closely to the limit of rate and size of material to insure excellent results under all conditions of quality of applied water. The cost of purifying water is not a heavy burden, and there is no demand for reducing the cost at the expense of water quality. More perfect conditioning of the water, better sterilization, and the removal of tastes and odors, already have increased purification cost in many places; yet these improvements have met with the approval of water consumers as well as public health officials. We should not nullify some of the gains of this improvement in quality of water by lessening filter efficiency.

The author, not long ago, attended a meeting of filtration plant operators in which the discussion centered largely upon the efficiency of the plants in producing good water. Very few operators reported perfect conditions. Nearly all of them were troubled at times by cloudy filtered water, or by a gradual accumulation of sediment in the clear-water reservoir. Sediment in a clear-water reservoir is evidence of poor operation, caused either by poor coagulation or poor filter performance. Water may be improperly coagulated and not filter clear, yet the turbidity that passes the filters when they are functioning properly usually is so finely divided that it is not likely to settle in the clear-water reservoir.

Causes of Poor Filter Performance. Several things may contribute to poor filter performance; among them improper operation or carelessness, poor design, filtering materials being too coarse or too fine, and poorly conditioned water before filtration. Inefficient

filter performance can be attributed largely to lack of knowledge of the essentials for good filtration, or to failure to exercise care and judgment in operating the filters. Sometimes it can be attributed to laziness. Nearly all filter operators will perform diligently duties such as the opening and closing valves to operate filters and the keeping records; yet they will object to doing manual labor such as the use of a rake, shovel, or other device to break up hard spots in filter beds.

The author has often wondered whether operators feel that they should not be called upon to do this kind of work, whether they regard the work as too strenuous, or whether they feel that breaking up hard spots in a filter only to see them return shortly afterwards is a hopeless task. Whichever viewpoint is taken, the significant fact is that very little effort is being made by some operators to do all they can do towards maintaining filter beds in good condition.

The author takes the viewpoint that operators should not be negligent; that some duties require too much physical exertion and should not be expected of operators, especially when such work could be done with much less labor by a modest expenditure for equipment to produce better washing. The management and not the operator is responsible for some of the poor filter operation, for it has not given operators the equipment necessary for efficient operation. No one should expect the fireman of a small boiler plant to carry the ashes away from the plant on a shovel for a distance of several hundred feet when wheelbarrows are so cheap, although he may have time to do so. The fireman would revolt against such an order. Filter operators will revolt against jobs requiring excessive labor when they know that the same results can be accomplished with less labor if proper equipment is provided.

All filters should be equipped with means for avoiding as much as possible the formation of clogged areas and the pulling away of beds from their sidewalls. The latter so often precedes formation of clogged places. The author should like to urge that such improvements in filters be made as will enable them to be maintained in excellent condition with the least necessary manual effort.

Faults in Design May Cause Operating Difficulties

Hydraulics of Underdrain May Not Be Good. Sometimes the design of the filter is a contributing cause of filter beds getting into bad condition. This is true for some of the early designs, particularly

in plants where the water has considerable tendency to produce clogging trouble. Filters should have an underdrainage system that will insure good distribution of wash water. Any deviation from uniform application of backwash contributes to displacement of the gravel, and this is the forerunner of many filter-bed troubles.

The hydraulics of filter underdrains may not be understood so well as the hydraulics of the flow through straight pipes and channels, yet enough is known to design the underdrainage system so that it will insure fairly uniform distribution of wash water. Notwithstanding this knowledge, many underdrainage systems have been, and are now being installed, with uniform size of manifold and uniform spacing of openings in laterals. This statement applies more particularly to small filters. Such designs simplify construction but complicate operation. In very small units, in which manifold and laterals are frequently larger than necessary, slightly unequal distribution may not be of much consequence.

Manifold above Laterals Not Good Design. At one time, many filters were constructed with the top of the filter manifold higher than the top of the laterals. This made the strainers screwed into the manifold higher than those fastened into the laterals, as shown in Figure 6.

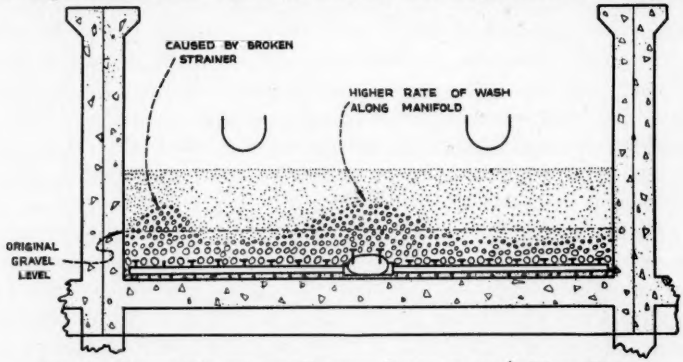

FIG. 6.—GRAVEL MOUNDED BY UNEQUAL DISTRIBUTION OF WASH WATER.

The author has had the opportunity of examining the filter beds in a number of plants using this type of underdrainage construction. In nearly every instance, the gravel was found to be badly disturbed. It was usually mounded over the filter manifold. This remark should

not give the impression that movement of the gravel is confined to this one type of underdrainage system alone. Gravel is moved about in nearly all filters in the course of time but more readily when the manifold extends above the laterals than when laterals join the manifold near its top.

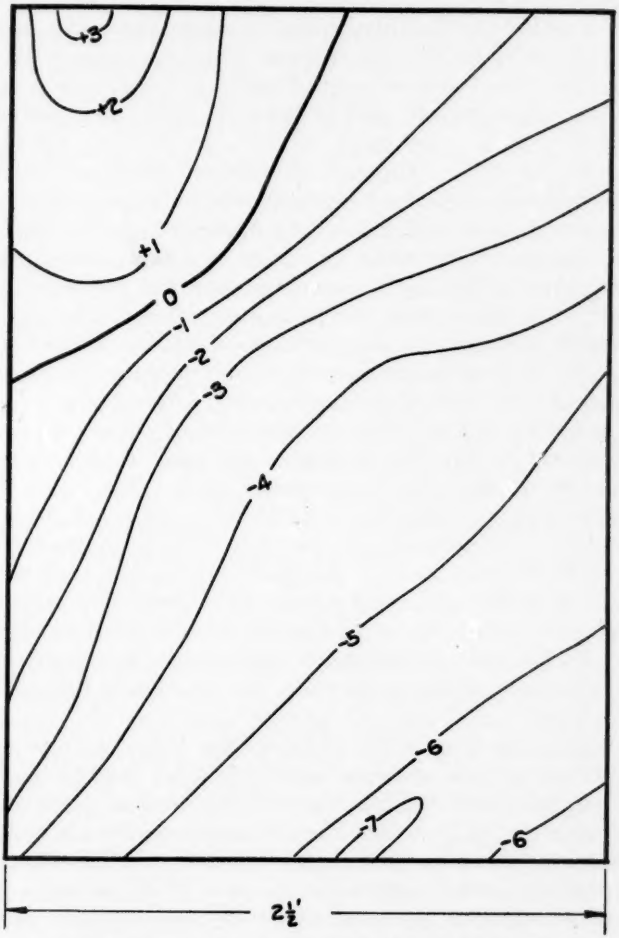

FIG. 7.—ONE-INCH CONTOURS OF THE GRAVEL SURFACE IN A FILTER.

Gravel becomes badly ridged or mounded in many filters, not only over the manifold. Other places are likely to occur in any part of the filter. So much of the fine gravel may be moved from one part of the bed to another part that sand will come into contact with such coarse gravel that the sand can work its way through the gravel.

Figure 7 shows the contours of the gravel surface in a small section of a filter that had been in service a few years. The maximum variation in gravel level in this area was 10 in. At one place the gravel surface was 7 in. below its original level, and sand was in contact with gravel about one-half inch in diameter. There was sand leakage through the gravel.

Surges in Filters. Surges in the effluent pressure of filters are great enough in some plants to interfere with filter performance. The surges seem to result from momentary fluctuations in the rate of flow through the filter. The filters in various filtration plants that have been measured for surging were equipped with standard makes of rate controllers. In some plants, the magnitude of the surge appears to be extended by poor hydraulic conditions in the filter-effluent conduit. The surges in some places, therefore, may be caused by hydraulic conditions in both the filter-effluent and the filtered-water conduit.

The surges originating in the filter-effluent piping appear to be caused largely by the high velocity of the water through the throat section of the Venturi tube of the rate controller. Partly closed valves produce surging, and when the valve is nearly closed at the beginning of the filter run the surging may be caused partly by the valve and partly by the Venturi tube. As the loss of head increases on the filter, the valve is opened wider and wider, and when fully opened nearly all surging then originates in the Venturi section of the rate controller. Rapid velocities through the effluent piping may increase the surging, although in many well-designed filters the velocities in the piping add very little to it.

Surges as great as 10 in. in the effluent pressure were observed in one filtration plant when the rate of filtration was 2.2 g.p.m. per sq. ft. and the loss of head on the filter was between 8 and 9 ft. In this instance the effluent conduit or air leakage into the filter effluent line evidently added to the surging. Surges in filters discharging directly into a reservoir were much less than 10 in. for the same rate and loss of head, although more than 1 in. Surges greater than 1 in. may increase the tendency of filters to pass coagulated matter. Poor

hydraulic conditions in filter-effluent conduits may be corrected so as to almost eliminate the trouble in this part of the line. Correction of surging caused by the rapid velocity of the water through the throat section of Venturi tubes may not be an easy task.

Trouble from Sand Leakage. Various troubles occur when sand passes through the gravel layer. Sometimes, so much sand gets into the underdrains that some of them become clogged. Frequently, the gravel also becomes clogged with sand in spots. This results in lessened washing in these areas and accumulation of mud. Soon hard spots are formed in the sand. Considerable leakage of sand may create a hole through the bed, allowing some unfiltered water to pass through the hole.

Sand leakage is often not sufficient to clog the underdrains entirely, and sand may be washed back and forth through the strainers or the openings in the underdrains. Some of the sand passes into the pipe laterals and is deposited in them when the filter is operating. When the filter is washed, part of the accumulated sand is forced back through the strainers or other openings into the gravel. The velocity of the water is such that the sand strikes the strainers, if strainers are used, with sufficient force to produce wear. Occasionally the metal of the strainer is worn away entirely. The writer has observed strainers with holes fully ½ in. in diameter worn through the metal, as shown in Figure 8. Such a hole in the strainer will produce a large jet of water during backwashing and may cause the gravel to be mounded over the strainer, particularly if several strainers with holes are situated close together.

When loss of sand is discovered, the sand and gravel must usually be removed from the filter, the strainers cleaned, if strainers are used, and damaged strainers replaced. The mixed sand and gravel must be sieved and replaced in the filter in accordance with its original construction, or new material must be used. The filter will then generally operate in a satisfactory manner until the gravel layers again become so displaced that sand begins to pass through the filter. The rebuilding of filter beds is expensive in some plants, for it has to be done almost every year.

Opinion varies as to what may be done to remedy mounding or ridging of the gravel. No filter bottom that includes gravel will insure freedom from such movement, and there may be no permanent remedy. Does anyone know of filter beds that have been in operation for

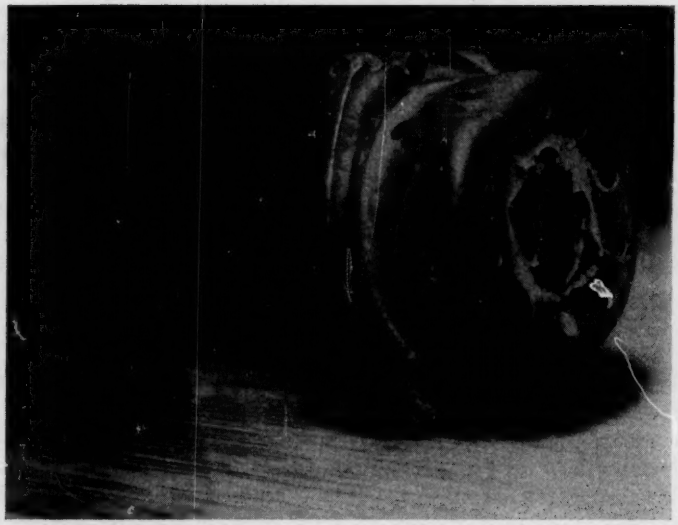

FIG. 8.—HOLE WORN THROUGH STRAINER BY SAND LEAKAGE.

ten to fifteen years in which the gravel surface has remained as constructed? Many believe it is better to rescreen the filtering material occasionally or even frequently than to reconstruct the bottom of the filter, especially when there is no definite assurance that the new type of bottom selected will be better than the old. Some of the filter bottoms in old filters are so well cemented into place that reconstruction of the underdrainage system would be expensive.

Sand Expansion Indicator. Instead of washing at some set rate, there are a few plants in which the backwashing rate is based upon sand expansion. The backwash valve is opened until the sand shows the desired expansion. A device for indicating expansion of the sand in filter beds is now available. It consists of a counterweighted float, having a specific gravity, when the weight of counterweight is subtracted, slightly greater than that of water. The float rests partially submerged in the expanded sand. The float is pushed upward with the sand as it expands, and while there is a tendency for it to sink deeper into the expanded sand as the bed becomes more and more expanded, this is an error of little consequence. The sand expansion indicator is believed to be a worthwhile addition to filters.

Filters Difficult to Rebuild. One drawback to securing filter improvements is that when the water delivered by a plant does not give rise to complaints, it becomes difficult to persuade the city council or the owners of the plant that rebuilding or extensive change in filter construction is desirable. Another drawback is that although we may say that filters are poorly designed we do not have good proof of the assertion. Perhaps most of us believe we know better methods of design, yet no one has produced a filter bottom which has remained in good condition while handling all types of waters. Either the ideal design has not been found, or there are certain inherent weaknesses that cannot be remedied. The latter is believed to be the reason. Even distribution of wash water can be produced, yet it is known that this does not eliminate filter bed troubles.

Effect of Sand Size. Although fine sand should filter the water more perfectly than coarse sand, it often produces so much trouble that better water is obtained by using coarser sand. Fine sand causes short filter runs, which mean more frequent washing, and may increase the amount of wash water required. The quality of the filtered water immediately after washing is generally not as good as it is after the bed has been in service for one hour or more. Increasing the number of washes may increase this trouble. Small sand grains have a greater tendency to become coated than do larger grains, thereby causing more shrinkage of the bed during filtration. The harmful effect of bed shrinkage was mentioned in the previous article.

Sand that is too coarse will allow coagulated material to pass through the filter more readily than finer sand, particularly at times when coagulation is weak. There is great variation in the strength of coagulation of practically all waters. Several factors affect this variation of strength, and it is not uncommon for the longest filter runs in a filtration plant to be several times the length of the shortest runs, providing the filters continue in service to the same loss of head. There are probably very few waters with which the longest runs are less than twice the shortest runs. This variation in the clogging tendency of water makes it difficult to select the most suitable size of filtering material.

The effective size of the finest filter sand that should be used for water that produces weak coagulation is about 0.35 mm. For the average water, sand of an effective size of about 0.50 mm. probably is about as coarse as should be used. With some waters still coarser

sand will produce satisfactory results. Where there is great variation in the strength of coagulation, it is probably best to use sand with ar effective size between about 0.45 and 0.50 mm. The filter runs probably will be short during periods when coagulation is strong, and long when it is weak. During the weak periods, it may be necessary to wash the filters at a low loss of head to prevent coagulated matter passing through the filters. Any filter that handles coagulated water with a turbidity of 2 to 5 p.p.m. in which the length of the run is over 50 hours at rated capacity should be watched for the passage of coagulated matter.

Air Binding. Many filters become air-bound at times. Most filters are constructed with the top of the sand bed about 3 to 5 ft. below the average water level on the filter. If the loss of head is allowed to increase to 8 to 10 ft. in such filters before washing, a partial vacuum is created in the bed. Water saturated or even slightly undersaturated with air at atmospheric pressure will become supersaturated if the pressure is lessened. Then it may release air in the filter bed. The first release usually occurs near the top of the sand, and as air continues to be released the volume of air increases and sometimes may occupy most of the void space in the bed.

Two troubles are associated with the accumulation of air in filter beds: More rapid increase in loss of head, and unsightly foam on top of the water while the filter is being washed. All of the foam will not be washed away unless a hose or some other means of agitation is used. The foam carries with it a small amount of sand, and while it may require some time to produce an appreciable loss of sand in this manner, nevertheless there is a gradual loss.

The velocity of the water in passing through the air-bound part of the bed is increased. This may reduce slightly the efficiency of the filter in removing the coagulated matter, but there is no specific proof that it does. The only way in which air-binding may be avoided is by constructing the filters so that there will be no partial vacuum on the water in passing through the filter bed. This indicates that filters should have a greater depth of water over them than is generally provided at present.

There is no sure way of telling if a certain water will produce air binding without trying the water in filters. Water has become supersaturated with air by leaks into the suction of the low-lift pumps. The leaks are in the form of small bubbles, and when the water is

placed under pressure after passing through the pumps some of the air is dissolved by the water.

Occasionally, operators cut a filter out of service, allow much of the air to escape either naturally or by forcing it out of the bed by turning on a slight amount of wash water, then the filter is turned back into service without being washed. Such a procedure may have

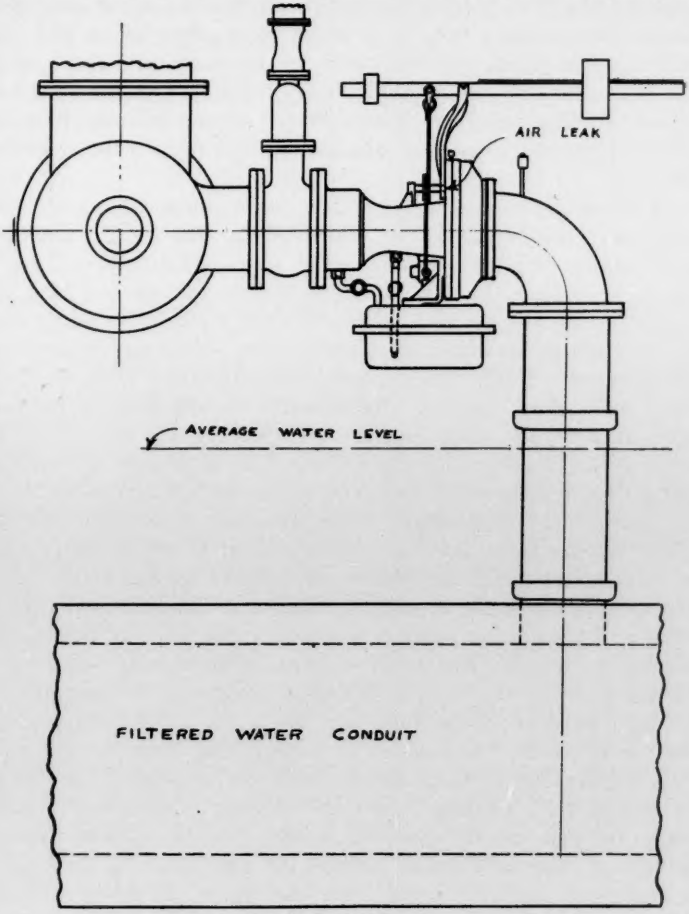

FIG. 9.—AIR LEAK IN FILTER RATE CONTROLLER.

to be resorted to where runs are short, yet it should not be regarded as good practice.

Air Leaks. The filter-rate controllers in many filtration plants are located above the hydraulic gradient of the filter effluent conduit or the clear-water reservoir. The hydraulic gradient in the filter effluent line beyond the rate-control valve therefore frequently lies below the effluent line. Any joint or connection on this line or the controller, which is under suction, may, if it is not tight, allow air to leak into the effluent line. Some rate controllers are so constructed that stuffing boxes are under pressure when the loss of head on the filter is low; in others stuffing boxes are always under suction because they are above the hydraulic gradient of the effluent pipe beyond the controller valve.

Direct-acting controllers must have stuffing boxes that exert little friction upon the moving parts. The packing, therefore, is not compacted tightly. Unless they are given frequent attention, there is likely to be leakage through the stuffing boxes, and air will leak into the line through boxes under suction. Figure 9 illustrates an arrangement in which air leakage may cause trouble. Often the filter-effluent lines discharge directly into a filtered-water reservoir underneath the filters. Air carried into the filtered-water conduit may cause more trouble than if the water and air are discharged directly into the reservoir. Air leakage into the suction of a filter may increase the surging trouble referred to in a previous paragraph of this paper.

Turbidity after Washing. Most filter operators are aware that the first water passing through a washed filter is not perfectly clear. The time in service before the water reaches its maximum clarity varies from 20 minutes to an hour or more. Figure 10 records the turbidity of the filtered water of a typical rapid filter during the first two hours of service. The water was treated sufficiently well to yield a turbidity of 0.1 p.p.m. after filtration, except at the beginning of the run. The illustration shows that the water did not filter to this clarity until about 100 minutes of service had elapsed. The cause of the slightly cloudy water coming from a filter when it is first put into service after washing is not the passage of coagulated matter through the bed, but the presence of fine colloidal particles that are produced by the sand grains rubbing off and breaking up some of the suspended matter filtered from the water. Prolonged washing would largely eliminate this, but would be too expensive.

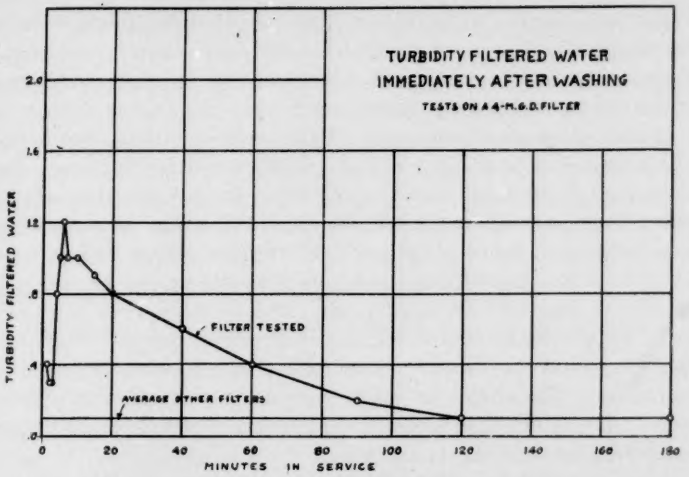

FIG. 10.—VARIATION IN THE TURBIDITY OF FILTERED WATER AFTER WASHING.

At one time it was customary to filter to waste for short periods at the beginning of the filter run. This required wasting so much water that it is not now common practice. The turbidity passing the filters following the wash is colloidal turbidity and does not settle in the clear-water reservoir or in the distribution mains. The author does not advocate returning to the practice of filtering to waste, yet the production of a slightly inferior quality of water when the filter is first turned into service after washing should not be ignored. It should receive further consideration to see if there are means for lessening this turbidity.

Filter Rate Controllers and Gauges. Anyone who has had experience in operating some of the filter-rate controllers manufactured 20 to 30 years ago, with their multitude of cords, pulleys, etc., cannot help being impressed with the simplicity of the rate controllers and indicating and recording instruments that are now being manufactured. The newer types of rate controllers are not free from operating troubles, but they are certainly a great improvement over the older devices. The author recalls in a plant he operated about 25 years ago that the indicating and recording devices were enclosed in a housing that required a block and tackle for its removal in order to give access to

the numerous cords and pulleys of the somewhat complicated mechanism that was used to transfer the rate and loss of head to indicating and recording devices. Since this operation was required at frequent intervals, such covers were troublesome.

Broken cords, cords slipping off the pulleys, instruments getting out of adjustment, and failure of the clock to operate, is giving some filter operators enough work to keep them busy when they are not washing filters, writing up records, and attending to the numerous other duties assigned to them. These devices should be kept in good operating condition, and repairs and adjustments should be made as promptly as possible. In large plants, this kind of work is handled usually by the repair force, but in small plants at least one of the operators should be capable of making the necessary repairs and adjustments. The chains or wires used to operate the pointers on the operating tables that indicate the position of the hydraulic valves are another constant source of trouble.

Four-way Valves. Simplified rate controllers and loss of head gauges leave as probably the most troublesome part of the filter mechanism in some plants the four-way valves that are used for opening and closing the hydraulic valves in the filters. These valves, as is well known, are attached generally to a small manifold underneath the filter-operating table, where they are controlled by levers on top of the table. Such valves usually operate under high pressure, which adds to the wear on the valve seats. If someone could perfect a four-way valve that would not give trouble after being in use for a period of a year or more, such a valve would lessen the troubles of many operators. Four-way valves have to receive attention so often that it may be good practice to take all valves apart at intervals of several months, rub the surfaces lightly with sandpaper and apply a little tallow or grease. This will not eliminate the trouble completely though it should be helpful.

When the valves are hard to turn, and they soon become so, it is an indication that something is wrong. Continued use of such valves soon scars their face and seat. A valve with too loose a seat will allow some water to leak through, and this also will scar the face and seat of the valve. Four-way valves in most plants, therefore, are a constant source of trouble.

Leaky Valves. Of the valves attached to the piping of filters, the one most likely to give trouble is the wash-water valve. The

pressure on these valves is usually considerably greater than that on other valves. Almost invariably, the wash-water valves begin to leak after a few years of service, and it becomes necessary to repair or eventually replace these valves. Frequently, they are allowed to continue in use until leakage reaches considerable magnitudes. Since filtered water is used for washing, there is associated with this leakage a higher cost of pumping water into the wash-water tank. Nothing can be done in operation to lessen the wear on wash-water valves, though such troubles indicate it is not advisable to locate the wash-water tank at too high elevation above the filters.

Improved Methods of Measuring Filter Efficiency

Probably one reason why not much attention is paid to filters is that we have lacked a good means for measuring filter efficiencies. Turbidimeters that will respond to low turbidities came into use a number of years ago, and while they enabled accurate turbidity determinations to be made upon the water, they did not distinguish between turbidity due to improper coagulation and turbidity produced by coagulated matter that passed the filters. A means for detecting coagulated particles in water by floc detectors has been devised and installed in a few filtration plants. While the device has not come into extensive use, it is useful in operating filters in which the coagulated matter is likely to be weak at times.

The chief disadvantage of floc detectors is that when they can detect coagulated matter more than the desirable quantity is passing through the filter. Another disadvantage is that occasional observations give no indication of the total amount of coagulated material that passes through the filter. Usually, very small amounts pass through during the first part of the run. In a few plants, however, a considerable amount may escape in the winter months during the latter part of the run if the filters are allowed to operate up to a high loss of head.

For the past several years the author has been giving consideration to more accurate methods for measuring filter efficiencies. The method which has proved most successful is to pass a small stream of filtered water through a small cotton-plug filter, allowing the stream to flow through the filter continuously at a rate of 100 to 150 ml. per minute. At intervals, that can be determined after use, the cotton plugs are removed from the filters, taking care to leave all of the

material filtered by the plug on the cotton. The plugs are then dried and ignited, and the ash is weighed.

Figure 11 shows a cotton plug filter and its rate-control mech-

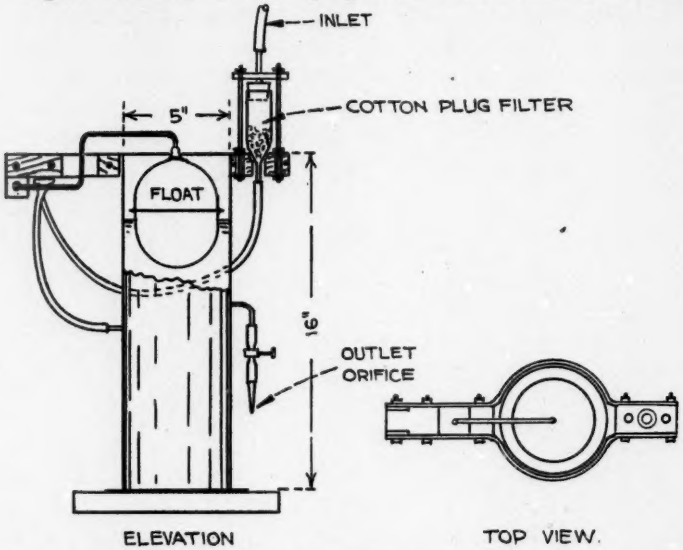

FIG. 11.—COTTON-PLUG FILTER AND APPARATUS FOR REGULATING THE RATE OF FLOW THROUGH THE FILTER.

anism. The device is connected to the effluent of the filter and is controlled by a float tank that is just large enough for operation of the float. A nozzle is attached to a tube inserted in the side of the tank and is so dimensioned as to obtain the desired rate of flow. The water from the large filter first passes through the cotton plug filter and then through a rubber tube connected to the float tank. The tubing passes between the lever of the float and its supporting arm and is pinched off as the elevation of the water in the float tank rises. The flow will be cut off completely before the float tank overflows. When the orifice is running, the level is drawn down enough in the float tank to produce the rate of flow corresponding to the head on the orifice. The flow will remain constant so long as the head through the cotton does not become great enough to obstruct inflow. There may be considerable fluctuation in the head of water on the cotton

plug filter, but with a float of the size shown flow through the apparatus will ordinarily be controlled accurately. Based upon rate of flow and time in service, the parts per million of ash can be calculated.

Experience with cotton filters over a considerable period of time indicates that they give accurate measurements of the coagulated matter passing through filters. The accuracy is much greater than that obtainable by any other known means. One gram portions of absorbent cotton are used for the cotton plugs, and ordinary laboratory glass filter tubes, 25 mm. in diameter at the top, are employed. A rubber stopper closes the tube and must be held in place with clamps as shown in the illustration.

Table 3 gives the ash content of the material passing through

TABLE 3—COAGULATED MATTER PASSING SAND FILTERS AS DETERMINED BY COTTON PLUG FILTERS

	Parts per Million of Ash				
Date	A	B	C	D	E
5-3-40	.016	.248	.106	.168	.075
5-9-40	.022	.149	.188	.072	.024
5-11-40	.010	.082	.267	.050	.029
5-15-40	.010	.104	.151	.025	.130
5-17-40	.025	.040	.129	.022	.025
5-24-40	.012	.012	.040	.009	.023
5-27-40	.016	.042	.046	.026	.226
6-3-40	.011	.031	.056	.015	.251
Average	.015	.089	.123	.048	.098

several filters. Filter A was operated like an average filter; the others were operated under conditions that were not expected to give good results. No definite figure can be set at present for the amount of ash that should not be exceeded in filtered water. Tests indicate that the value should be not more than about 0.025 p.p.m. The ash content in some other water may need to be another figure. One objection to this method of testing is that filters in one plant probably cannot be compared accurately with filters handling a different character of water. The tests are useful, however, in comparing filters in any plant with each other. The cotton plug filters are not difficult to construct or expensive to operate, and they do not produce much additional laboratory work. The information obtained is of such value that it is better to curtail some other types of laboratory work, if necessary,

in order to have time to burn and weigh the cotton plugs. Certainly the results obtained are of more value than some of the tests commonly made in filtration-plant laboratories.

SUMMARY

The operation and maintenance of filters in water treatment plants are important parts of the duties involved in running such plants.

Chlorination and good conditioning of the water has lessened the necessity for high filter efficiency, and this is causing the filters to be neglected in many places.

The duties of filter operators vary, depending upon size of plant. Written instructions defining the duties of filter operators and the procedure to be followed in washing filters bring about more uniform operation and care of the filters. A procedure for washing filters is recommended.

The drift towards the use of coarser filtering material and faster rates of filtration is now approaching too closely the limiting size of material and rate of filtration to insure excellent results under all conditions of water quality.

Poor filter performance may be caused by poor design, the filtering material being too coarse or too fine, poorly conditioned water before filtration, improper operation, lack of knowledge of the essentials of filtration, or failure to exercise care and judgment in operating filters.

Filter operators should not be neglectful of their duties, and the management of the plant should see that equipment is provided which is capable of efficient operation.

A poorly designed filter bottom contributes to the displacement of filter gravel. Shifting gravel may cause sand leakage and mixture of sand and gravel. To remedy such conditions the beds have to be reconstructed.

Sand leakage causes trouble in many filtration plants.

Surges occur in the effluent pressure of filters and are caused by the rapid flow of water through the Venturi part of the rate controller. Sometimes the surging is great enough to interfere with filter efficiency in removing coagulated matter from the water.

Air-binding of filter beds causes the loss of head to increase more rapidly. There is some loss of sand in washing an air-bound filter.

Leakage of air into the filter-effluent pipe causes trouble in some filters in which the pipe lies above the hydraulic gradient.

After a filter is washed, the water will not filter perfectly clear for a short time after placing the filter in service. The turbidity is caused by fine colloidal matter and not by coagulated matter that has passed the bed.

There has been improvement in filter rate controllers and in indicating and recording gauges within the past few years, but such equipment still is not free from trouble.

The small four-way valves for opening and closing the hydraulic valves and leaky wash-water valves are a constant source of trouble in many filtration plants.

An improved method of measuring filter efficiency is described. A small portion of the filtered water is refiltered through a cotton-plug filter which is attached to the large filter. The cotton with its accumulation of sediment is removed at intervals, burned, and weighed.

The writer wishes to express his appreciation to Messrs. Loran D. Gayton, City Engineer, and Arthur E. Gorman, Engineer of Water Purification, for permission to present this paper.

PROMOTING TAXPAYERS' INTEREST IN THEIR WATER SUPPLY

BY CHARLES SCHWARZLER*

[*Read September 27, 1940.*]

The superintendent or operator of a pumping station or filtration plant, like a manufacturer or any other business man, has a commodity to sell. Unfortunately, most people consider water to be a free blessing and do not fully appreciate the money value of the service rendered. There is an old story of a darky preacher who met with objection when he asked for the collection; his audience protested that salvation was free, like water. "It is," replied the Parson, "but you have to pay when we pipe it to you."

Today we do more than simply pipe water; we raise it, treat it, and practically guarantee it. And, since we have a commodity or service to sell, we face the same problem that a manufacturer must face, namely, interesting the user, or more correctly, gaining his willingness to pay for what he gets. A manufacturer can advertise, and create a desire for his product, but very few water departments are fortunate enough to have an advertising appropriation. There are at their disposal, however, means of advertising that require thought and work, but relatively little financial expenditure.

The manufacturer advertises because he must create a desire for his product, familiarize the prospective customer with it, and finally make the sale when the customer has reached the point at which he is willing to exchange money for the product. Superintendents of water works have a different problem, in that their customers have already received the product. The task then is to see that water consumers are familiarized with the product and service rendered and so become willing to pay the bill rendered.

Water departments that have made a definite bid for public interest experience much less difficulty with delinquent bills, complaints, and objections to tax assessments for expansion or rebuilding than those that make no effort. If such a program serves to gain the cooperation of the taxpayer, it is most assuredly worth a lot of effort.

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Some may reply that the public is a nuisance; that to educate taxpayers through visits to the plants places an added burden on the operators. The manufacturer might take the same view with regard to advertising; it is expensive and time-consuming—but it is the only practical way in which manufacturers can familiarize the purchaser with their products.

There is little question but that we get results out of any endeavor, in proportion to the effort we put into it. It is also true that the returns from such an investment will be pretty much determined by the wisdom of the efforts of water works officials. Therefore, the superintendent who harbors an idea of embarking upon a plan for winning taxpayer interest, should make sure, first of all, that the personnel, office, and plant of the department are prepared and ready to play their part in the plan. For there is no denying that visitors are something of a nuisance, even though they be taxpayers. Moreover, it will soon be discovered that they are a critical lot.

As a starter, there is the problem of employee education. Every employee in the organization should be schooled in the ramifications of the system; that is, every employee should be encouraged to take sufficient interest in the organization to know in general how it works and what its correct relation with the public is. Employees will be found more than willing, in most cases, to receive this schooling. People are more interested in those things with which they are familiar, and employees are more apt to take an interest in the organization's problems if they are made to feel a part of it. In a small town, the outspoken interest and loyalty of the staff will be of particular help.

Next, the office should be neat, with an atmosphere of courtesy and welcome. It does not have to be pretentious; but it should be remembered, always, that the product is pure water, and an office that is dark and musty (like too many municipal offices) is out of harmony with this product and business.

The Complaint Department deserves the most tactful and courteous person that can be found. People who are chronic complainers are usually of the type who make mountains out of mole-hills and are quick to resent impatience, indifference, or any attitude that can be construed as discourtesy. Considerate and patient treatment is the most disarming defense against the chronic kicker.

The appearance of the plant is of great importance. It must testify to its own ability to deliver a clean, palatable product.

Postings of grounds should invite rather than threaten. The author has repeatedly noticed a sign on the road leading to the pumping station in the little town of Foxboro, Massachusetts. The sign blares out—"Positively No Trespassing—Waterworks." To the author's way of thinking, this sign might better read—"The Foxboro Pumping Station—You are invited to visit the station at any time between the hours of 9 a.m. and 4 p.m. on any week-day, or by appointment by calling Foxboro 159." If areas around wells or reservoirs should be free from trespassers the sign could well read—"This is the Water Supply of the Town of Foxboro. For sanitary reasons please do not trespass."

These basic points are mentioned: developing a personnel that will coöperate in the matter of proper relationship with the customer; office appearance; plant appearance and posting, because if taxpayer interest is being coaxed, the setup of the whole organization is going to be subject to scrutiny. It will be difficult to get a person even to consider visiting a pumping station or filtration plant if his experience with meter readers, bill collectors, or office employees has been unpleasant. If he is induced to visit the plant, it will be difficult to talk of water purity and convince him that it is inside the pipe, if cleanliness and attractiveness are conspicuous by their absence from every place else. But these points are really essentials of any well-run business, anyway; therefore, they should not represent any additional expense. If all of these points are in order, the problem is merely one of developing that taxpayer interest, and the department is well-prepared to go ahead.

In smaller cities, say under 150,000 people, the best medium of contact is the local paper. The superintendent should make sure that the stories are well written. He should make certain that every additional piece of equipment or improvement in handling transactions, if it has news value, gets the publicity it should. This is a relatively easy accomplishment if there can be developed in the editor an intelligent interest in the subject of water and waterworks. The superintendent should not mind whether he likes the editor personally, or whether there is agreement in particular views; business is business, and the goal is a smooth-functioning waterworks organization that gets what it needs with the least effort. We should remember that all of us, with few exceptions, like to deal at length with those things

with which we are familiar; and the converse principle is: make a man familiar with a subject and he will deal with it at length.

The local editor should be the first to receive any facts that have news value. It should be remembered that he is supposed to be the source from which all news emanates. Particularly interesting articles that the superintendent comes across in water works periodicals should be sent to the editor. Most editors welcome interesting material of this kind, to sandwich in and break up the monotony of town gossip and reports of social functions. Many of the little items that are taken for granted in the water works field are new and interesting to the layman. Asking the editor's opinion will frequently win loyal support. Of course, if his opinion is known to interfere with water department plans, it is common sense to avoid asking, in that particular instance. But usually the case can be stated so that the editor's opinion and recommendation will work in with the plans. If the department's idea becomes the editor's own idea, his support and a good share of news or editorial space will probably be obtained.

New equipment, results of favorable water tests, new bookkeeping equipment for speed and accuracy in issuing bills, new personnel; all these are items of interest, that help to make the taxpayer familiar with what and how his water department is functioning.

A second method that requires very little outlay is the use of stickers attached to bills. It has been tried in many cities with more or less success. The instances of "less success" might warrant checking as to the way in which these notices were worded, and also as to how well they were followed up. By that this is meant: if people are invited to visit an office or a plant, they must be made to feel welcome when they get there, and there must be something there to see. These stickers should have a friendly but dignified air, working for a general feeling of coöperation. Typical examples might read:

"We have just received our semi-annual water analysis report from the State Board of Health. Our city still has one of the best water supplies in the state."

"Have you seen our new pump? Only half the size of the old unit, yet it pumps twice as much water with hardly a whimper. Incidentally, the old unit, still serving as a standby, has pumped faithfully for 40 years."

"Our new elevated tank will double the city's water reserve and

greatly increase our safety factor, having ample capacity, even under the greatest fire demand."

Little reports such as these, in sticker-form, can advise of the progress of new work from time to time, especially any work that tends toward improvement of overall conditions.

The next and most important step is to promote and prepare for plant visits. There is probably no taxpayer vote that is more safely assured than the vote of a man who is shown through a business-like plant and given an explanation of its function and performance which he can understand. High-school students are future taxpayers; and they take an active part in the family discussions. It is a great mistake to overlook or to neglect these young people. Instructors in general science, physics and chemistry should be familiarized with the plant layout so that they can make their class visits of an instructive nature.

But, before urging people to visit the plant, one should be certain that it is in a presentable condition and that visitors can be guided through it safely, protected from moving machinery and against other hazards. It is equally important that the guides shall be able to tell a coherent, easily-understood story of the plant and its operations. The local editor can be of immense help in helping to prepare such a talk; and also in reporting such visits as are received.

We might inject a word of caution right here, that the returns from any effort of the sort we are considering are excellent, so long as the effort is carefully planned and followed through to completion. But, whatever plan may be undertaken: before attempting it, one must recognize that it must be carried through to the *end*, and that this involves continual work and constant guidance on the part of the water works official. When his own interest in the program begins to subside, the end of the program is in sight.

First impressions are important; therefore, the introduction to a plant site is important. Grounds that are carefully planted and cared for are beautiful, but they do cost money. Yet, natural landscaping can be equally pleasing, and it requires much less care and expense. A tidy lawn is more a matter of mowing and raking than of anything else; and it takes work, rather than money, to make a lily pool out of a swampy area of cat-tails.

Local garden clubs will frequently be of much help; but the job should not be turned over to any club, or group of clubs, without

reserving *and exercising* the right to approve all plans and plantings. More than one superintendent has been "done up" with beds of annuals that were gladly planted in the spring and sadly neglected as the summer vacation season moved along. We all have an urge for the dirt in the spring sunshine, but we must be really interested in gardening to carry on through the summer months. The coöperation of the local garden club should be graciously acknowledged, if offered; but the use of water works grounds should be held out as a privilege to be relinquished whenever adequate attention is not given to the plantings.

If a reasonable appropriation can be afforded for ground maintenance, its advertising possibilities should not be overlooked. The advice of someone who really knows the principles of effective and correct landscaping should be obtained. Grounds should be planted for attention-getting value, displays being massed in order to have something to feature; then bill enclosures or stickers can read:

"Don't miss the Forsythia on the south bank of the grove. It will be at its best about April 15."

"The new Yellow Queen of May is now out, in the main lily pool."

Picnic groves can be an asset but should not include the playground layout. That should be left to the playground committee, because it requires too much supervision. It is enough if some well-constructed fireplaces and a central shelter for shower protection are provided. Sticker notices can then call attention to desirable picnic periods. Special picnics should be reported. Convenient disposal receptacles should be provided, and cleaning up should be enforced, without exception. Then there will be little work to the maintenance of this asset.

Of course, from the point of view of the water-works official, the picnic ground serves only one purpose, that is, to help the taxpayer become familiar with the pumping or filtration plant. Therefore, to carry through, the area should be properly posted. A neat sign or plaque on the pump-house or filtration plant should give the pertinent information that people naturally want. For example, the sign might read:

"Foxboro Municipal Pumping Station
Built in 1932

Water is pumped from driven wells to the altitude tank located at Knob Hill, a distance of 1¼ miles and a height of 230 feet.
Pumps—One, Diesel-engine driven, 150 gallons per minute.
One, electric-driven standby, 75 gallons per minute.
Well depth—Average 20 feet.
Water pumped per day—100,000 gallons."

The well area might properly be posted with information regarding the number of wells, type, depth, etc., with the main part of the sign reading:

"Please do not trespass on this area."

If a new plant or a program of modernization is under consideration, there is a particularly good reason for starting a plan for promoting cordial public relations. The architect and consulting engineer are going to spend money on the esthetic features of the plant; really these might be considered the advertising features. We do not pay for face brick, limestone trim or bronze lighting fixtures because they improve the water or make the pumps run better. The pumps will do just as well in a cubicle of cinder block. No, we make our plants attractive, nowadays, for a very different reason. Most of the investment in a water plant is underground, or on equipment supposedly of no interest to the layman; and it is, therefore, considered wise to allow $20,000 or $30,000 extra to make the plant good-looking, so that there will be something to show for an investment of $100,000 or $150,000.

It will be well to consider in connection with building plans whether it is not worth an increase of 1 or 2% in the total outlay, or even a reallocation of some of the "dress-up" allowance, to help to sell the product. We must demand, in any new layout:

1. A neat, workmanlike but not pretentious plant.
2. The inclusion of safety and display features, in consideration of the fact that it is desirable to invite the public.
3. A plant that will emphasize and help to sell the product.

Officials will go a long way toward achieving the first of these requirements, namely, a neat, businesslike, but not pretentious plant, if they have given some thought to this matter before the job reaches the architect or consulting engineer. These men are always faced with the problem of analyzing the requirements so that they will wind

up with a satisfied customer. They are usually grateful for any preliminary suggestions that can be made, for they are anxious to satisfy. Certainly there is no reason why a pumping station cannot be housed in a building of Cape Cod cottage design, similar to the attractive and inviting gasoline service stations that we see along the highways, as well as in an ugly structure, and the architect will be all the happier to work on an artistic job.

It is to be regretted, that we in New England do not make more use of the pleasing colonial architecture that is our inheritance, in the construction of our municipal buildings, schools and other structures. The lines lend themselves admirably to the use of new materials and modern construction methods. However, the more severe modern lines are exceptionally well suited to pumping stations and filtration plants, and different types of architecture may be the most suitable and harmonious in different locations. Architect and consulting engineer, by tactful suggestions, can be depended upon to provide plans for an efficient, businesslike looking building that is certain to get the wanted attention.

A little careful planning will give a plant that can hold open house 365 days in the year. By locating pumps or control boards in rooms equipped with bay windows or glass panels, interest is invited. Expensive?—not necessarily. It depends on whether one insists on a 10-ft. by 10-ft. plate glass window, or whether, by clever architectural treatment, 3-ft. by 6-ft. glass can be used or even a colonial type of window made up of panes of standard size.

Galleries add little to the building size, yet they provide a safety factor. Balconies should not be set so high that visitors lose a sense of intimacy with the equipment; the gallery needs to be raised only three or four feet, with guard rails at several arms' length from the equipment. In a plant thus arranged, explanation is simplified when a guide or attendant is on hand.

Recording and indicating flow, pressure, and temperature instruments are always intriguing. Too frequently we pass up the attention value that might be gained from a neatly laid out panel board that is properly placed. It can serve as a focal point for explanation and understanding of the plant. We can take a leaf from the plan book of radio broadcasting stations; they always put the equipment behind glass panels or in windowed operating rooms. This lends an air of importance and a sense of accurate control to the whole plant.

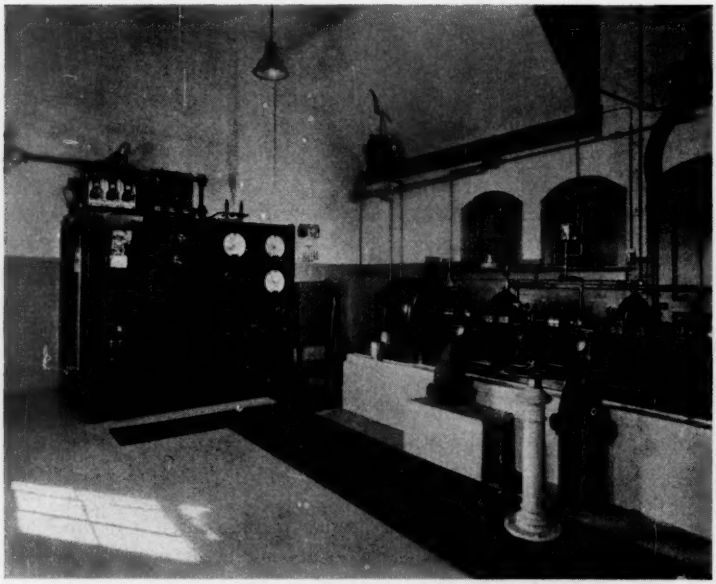

FIG. 1.—Visitors to the Pumping Station at Mansfield, Mass., are favorably impressed by its spotless walls, the sparkling polish on bright metal parts, and the general atmosphere of neatness and efficiency so appropriate to the public health service that the station performs. The compact panel board, seen in the background, helps to simplify the explanation as to how the town's water supply is maintained and controlled. The four Foxboro instruments are: (1) upper, left: flow meter, recording total daily pumping; (2) upper, right: pressure gauge, recording the head of water in the system; (3) lower, left: Rotax Indicating Controller, operating the vacuum pump on the well; (4) lower, right: the Recording Controller of a Foxboro Teletax Liquid Telemetering System, the operation of the pumps at this station being automatically controlled by the water level in the reservoir, nearly two miles away.

And a centralized control room does not need to cost more than a few hundred dollars extra, since most of this equipment is required anyway, but would otherwise be spread out around the plant.

For instance, in the layout of a large pumping station or an ordinary filter plant, an impressive central control room, of interest to every visitor, is easily rendered possible to-day by making use of standard indicating, recording and control equipment. Instead of installing an influent and effluent gallery, with operating tables, all the operating instruments can be grouped on a central panel, forming the central feature of the main lobby layout. A step farther, which

FIG. 2.—Under this broad, flat mound is the concrete reservoir of the water system for the Town of Mansfield, Mass. In the valve pit, beneath the brick shelter, is located the transmitter of the Foxboro Teletax Telemetering System, which controls the operation of the pumping station, nearly two miles away, to maintain the correct water level in this reservoir, on top of Foolish Hill.

entails very little additional expense, is to include, as a center section of this panel, a flow diagram of the plant with indicating pilot lights located at the various points of control, to show high, normal and low flows, heads, levels and pressures. Valve locations can be spotted with red and green indicating lights to show valve positions. Such a board makes it easy to explain the whole operation of the plant; at the same time, such a control board has definite utilitarian value in that it makes supervision extremely simple. By the use of solenoid or motor-operated pilot valves, small toggle switches can be included on the flow diagram, to provide finger-tip control of all valves and motors throughout the plant. And, to repeat: this modern plant engineering need not run the cost out of line, if proper planning is done.

The lobby can form the focal point of the entire plant, with such an arrangement. By eliminating the effluent gallery and making the

influent gallery a neat cat-walk, funds can become available that can be allotted to the lobby layout.

Last but not least, it must be remembered that the product is PURE WATER—have it in evidence. An attractive and inviting drinking fountain should greet the visitor; the expenditure for this can well exceed the cost of the usual standard white enamel pedestal. Decorative fountains inside or outside, properly stocked with aquarium life, require little care, yet they certainly help to emphasize the attractiveness of the product that is being provided for the taxpayer. The picturesque aeration pond can be turned into an effective fountain display, especially if illumination can be afforded.

But each of the suggestions offered here requires careful consideration on the part of the water works official. Possible plans and improvements must be weighed against each other and investments thoughtfully considered. Otherwise energetic salesmen of instruments, panel boards, or illumination equipment may carry some of these suggestions so far that the expense will be entirely out of line. And that result is far from the intended purpose of this discussion. We have been considering ways and means for widening and improving the acquaintance of the tax-paying public with the water supply system, its operations, and its problems. We may call it "advertising" if we wish. The final conclusions are these:

Much can be accomplished with little or no additional expense. Advertising pays. It can help win and maintain the taxpayer interest. The rewards repay the effort invested; but any program to be successful, requires sound planning, intelligent guidance, a good measure of enthusiasm and interest, and a certain amount of good old-fashioned work.

PROBLEMS IN THE MANAGEMENT OF MUNICIPAL WATER WORKS

BY L. R. HOWSON*

[*Read September 26, 1940*]

The term "management" as used in this discussion is much broader than the usual understanding of the process of operating a water works system. As here used, "management" includes a well formulated construction program, a sound financial policy, economical administration of operations, and the equitable allocation of revenues through the medium of fair rates, all coördinated into a unified inter-related whole.

The normal American water works is a growing institution. In pre-depression times, the average American city added about 3% to its population each year. Inasmuch as the expansion of water facilities in general parallels the growth in population, the expenditures for new construction to care for this expansion have averaged about $1.50 per capita per year. It is apparent therefore that a substantial part of the total water works revenues has been required for financing new construction either directly from earnings or indirectly through fixed charges on construction cost. This proportion of revenues has varied from 10% to 25% of the total. In recent years, due to the depression, the rate of population growth has been relatively slow in most cities, but due to the ever rising standards of water service the investment has continued its growth. In cities that exceed the general average rate of growth, that is, approximately 35% per decade, the requirements for capital expenditures will necessarily be larger and methods of financing, other than outlined herein, may be necessary. This discussion relates primarily to the average American city.

Every municipal water works should be self-supporting and self-perpetuating. The revenues and the rates on which they are based must be adequate to support the present service and to provide orderly expansion to care for the growth in water requirements. Adequate water rates and sound construction and financial policies go hand in hand.

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Financial Policy. It is believed that municipal water plants should develop a sound financial policy through rates that will provide sufficient revenue to pay operating expenses, interest and amortization on outstanding debt, if any, an amount sufficient to cover ordinary additions to the water works, such as distribution system extensions and meters, and furthermore an amount to cover the average annual requirement for major additions. The obvious result of such a financial policy is gradually to retire all outstanding indebtedness and to build a well distributed construction program from revenues.

It will be noted that in this itemization of funds to be secured from revenues nothing has been said about depreciation. It is the author's belief that if the present generation of consumers pays interest on the outstanding debt, if any, and provides for its amortization requirements, and in addition pays for new construction out of earnings, it is certainly the responsibility of succeeding generations of consumers to provide for replacements of property from their current revenues. To charge present consumers for both amortization of debt and depreciation reserve for replacement of previously amortized property is an unwarranted duplication of charges.

Considered over a long term, the cost of financing from current revenues is only about 60% as costly to the consumer as financing by bond issues. Costs are amortized as incurred without interest charges. Financing from current revenues has several other very definite advantages, including the following:

1. Through being able to provide new construction when needed without resort to bond issues, the facilities are available when needed, and a high standard of service is uniformly maintained.

2. Delays incident to the failure to vote bond issues and the political exigencies surrounding their passage are obviated.

3. When coördinated with a properly developed, comprehensive construction program, the bulges in fixed charges incident to bond issues are avoided; and most important,

4. The attention of the consumers is focused upon *service* rather than *cost* as is the case when financing is done by bond issues. By financing new construction from revenues the Water Department, rather than the politician, has control of its ability to finance and furnish adequate service.

Construction Program. It is desirable that there be as few changes in the rate structure as practicable. If new construction is

financed from current revenues, it is important, therefore, that construction expenditures be well distributed. The prime essential to the distribution of construction expenditures is the formulation of a carefully studied, comprehensive program covering the requirements for expansion to serve both the near and distant future. Such a program should currently be made and kept 20 to 30 years ahead of the present time. It should be reviewed at periodic intervals not exceeding 10 years.

The formulation of such a program necessarily starts with a forecast of population, industrial growth and water requirements. Each part of the present system is investigated with respect to its ability to meet these requirements, its present and probable future deficiencies and the time when it will become deficient, and the various practicable means of correcting deficiencies are outlined, estimated as to cost and evaluated.

With such a well formulated construction program, it will usually be possible to so forecast requirements with reasonable accuracy and to so provide construction essential to meet them that the flow of capital into construction can be kept at a relatively uniform rate. Where such a construction program has been formulated and adopted, the following results have usually been accomplished:

1. Funds are provided for construction when needed and not before; thus on the one hand saving the fixed charges on expenditures which otherwise might be made before they are necessary, and on the other hand obviating the inadequacies in service resulting from delays in building large expansion programs.

2. It effects the most practicable uniformity of construction requirements and expenditures. Construction expenditures follow a smooth line rather than a saw tooth course. Smaller expenditures for construction are made each year which is preferable to accumulated deficiencies corrected at infrequent intervals.

3. By such a comprehensive program of development, each year's construction is designed to serve not only the immediate needs but to fit in best with the ultimate requirements, thus minimizing future obsolescence.

Economical Operations. It should, of course, be the aim of all management to operate as economically as possible consistent with furnishing excellent water service. Sometimes, but not as frequently as ordinarily thought, there is political interference in municipal plant

operations which adversely affects economy. Economy in operations does not just happen; it is created. Among the factors contributing to it are:

1. Good bookkeeping and accounting practice.
2. Concise yet comprehensive daily, weekly, and monthly comparative operating reports.
3. An annual report, properly arranged for comparative use.
4. Comparison of operating statistics of the particular plant with others of its type and class.

Good bookkeeping is essential to economical administration. The introduction of standard methods of accounting for water utilities by state utility commissions has been of great advantage. Unfortunately in most states, the adoption of this system is mandatory only for private utilities. It is believed that every municipal water works should adopt standard accounting practice without being compelled to do so. The use of standard accounting methods has been of great advantage to the private utilities; it will be of even greater advantage to municipal plants whose accounting practices are frequently more lax. There should be a system of daily, weekly, and monthly reports from department heads to the manager. These should be informatory rather than routine, brief, yet sufficiently explicit to enable the manager promptly to detect and correct variations from normal.

Municipal water works should prepare their annual reports along standard lines. Some years ago a joint committee of this Association and the American Water Works Association prepared a form titled "Essential Statistics for Annual Reports of Water Works". Messrs. Metcalf and Rogers represented this Association. If all municipal plants would use this form,[1] the comparison of the individual plant's operation with others would be much facilitated and much more accurate.

There are two primary reasons for an annual report:

1. *The Beneficial Effect on the Management Itself.* Just as the author of a paper usually derives more benefit from its preparation than those who read it, so the greatest benefit from a good annual water works report falls upon the management. The preparation and analysis of the statistical data is essential to the best understanding of one's particular property. The preparation of the annual report should not be a routine matter consisting of tabulations by

[1]See Waterworks Manual of the American Water Works Association.

accountants compiled once a year. Its data should be constantly before the manager or superintendent, month by month, in form to disclose any variations from previous months or years.

Good management detects variations in operations when they occur, not later. A good report is a live, potent, functioning essential of management rather than a dead recital of past occurrences.

2. *Its Value in Indicating Possibility of Improvement.* Sometimes we learn much by a comparison with others in the same line of endeavor. If the annual report data are in standard form, comparison is facilitated and greater accuracy assured. By comparison, items are easily selected for more detailed analysis. For illustration, in a recent water rate investigation where it was first of all necessary to determine the reasonable operating expenses of the future, it was found that the unit costs of meter reading and collection were approximately double the average for other cities of similar size. An investigation disclosed that there were currently approximately 30% of the consumers delinquent and the total delinquencies amounted to one-third of one year's revenue. All current bookkeeping was done by machine, but delinquencies were transcribed to the bills by hand. This handling of about 30% of the accounts more than doubled the normal cost of collection and bookkeeping in that particular city. It was accordingly recommended that every effort be made to reduce the present delinquencies, that a firm shut-off policy be adopted and followed without political interference, and that in cases where it was claimed that absolute poverty prevented payment of the bill, the "trickle treatment" be administered. This consists in placing a perforated disc in the consumer's connection with an opening so small that the flow is restricted to an amount that will furnish water for the absolute necessities of sanitation but that requires so long to fill a bucket or tea kettle as to provide every incentive of paying the bill as soon as possible. The "treatment" has been quite successful in reducing delinquencies.

By analysis and comparison with other cities of comparable size it was found that in a particular city, while all other departments were relatively efficient, the commercial department was inefficient throughout. The average number of meters read per employee per day was approximately 30, and the number of bills rendered per clerk per day was less than 20. The annual commercial expense of meter reading, collecting, billing, and accounting averaged approximately

$3.00 per meter as compared to a general average of $1.50 or less. The number of consumer accounts handled per employee was only approximately 600 per year as compared to a general average of 1,200 and an outstanding performance, such as Cincinnati, of nearly 1,800.

In another city it was found that the automobile expense was excessive by comparison with 14 other cities in the same general population classification. It was found that the number of cars per 100,000 population was 22 as compared to the average of 12½ in the other cities, and the number of cars per 100 miles of mains was 10 as compared to the general average of 5.5. Investigation disclosed that these cars were individually assigned, unmarked except by a special license plate, that the average mileage per car per mile of main in the system was approximately 2½ times that of the average in other cities, that the average annual cost expressed in terms of dollars per mile of main or per capita served was about three times that of the average city. By a pooling of cars and the providing of a central garage, a saving of approximately $40,000 per year was practicable.

These figures are cited simply as illustrative of the benefits that can be derived from keeping records and cost accounting in cities standardized. The management in any particular city should check its operations with those of similar cities and plants and if the figures are accounted for on the same general basis, they will furnish a helpful guide in locating weak spots in its own organization. Every large organization has some department head with bureaucratic tendencies, sometimes so gradual in their expansion as to escape detection unless checked comparatively with the experience of others. Good reports help to "know thyself" and to do as well as or better than others.

Factors Affecting Water Rates. It is the function of the rate schedule to allocate equitably to the various classes of consumers their proper proportions of the total revenue requirements. One of the principal factors in determining fair rates is the proportion of total pumpage that is revenue producing. Obviously the lower the percentage of revenue water the higher the average rate per 1,000 gallons must be. This percentage is affected by such policies as ownership of meters, free water, use of hydrants, etc.

Ownership of Meters. In a considerable number of municipalities the meters are owned by the consumer. Usually when repairs to the meters are made, the consumer pays the expense. A survey of over 80 completely metered water works, classified only with respect

to ownership of meters, disclosed the fact that the meters were registering about 6% less of the pumpage in cities where the consumers owned the meters than where they were owned by the utilities. The reason is obvious. The consumer is not interested in accurate registration. The more inaccurate, the better for him, as a water meter cannot over-register. With increased wear the underregistration increases. Meter repair is an annoyance and expense to the private owner but a means of increasing sales and revenues to the city.

A further disadvantage in consumer ownership arises from the fact that during the period while the meter is removed from his service for inspection or testing, the water is usually furnished to him unmetered through a "jumper" connection. Investigation of consumer ownership practice has disclosed that frequently a "jumper" connection is in position for two months or more. Had the meter been owned by the city, it would have been immediately replaced by another meter. There would be no reason to return the identical meter removed. The meters are the "cash registers" of a water works. As such, they should be owned by the utility, not the consumer. Ownership by the utility, with the accompanying obligation of bearing the cost of repairs and renewals, will ultimately return several times the added expense through increased registration from the reduction in "unaccounted for" water. There is no more reason why a water consumer should own the meter than that a car owner should buy his gasoline measured by the tank of his car.

Size of Meters. The utility rather than the consumer should make the decision as to the size of meter to install on a service. Analysis of the "unaccounted for" water in a number of plants indicates this decision is worth approximately 5% in the water measured by the meters and sold. One of the most effective means of regulating the demand by consumers for oversize meters is by the inclusion in the rate schedule of a graduated "service charge" or graduated "minimum charge". Theoretically this charge should vary approximately as the ability to use water, that is, as the area of the pipe opening. However, in actual practice, as shown in a recent paper by E. W. Moke,[2] the increase is much less. Taking a 5/8-in. meter as unity, in average practice, the service charge for a 1-in. meter is approximately 60%, a 2-in. meter 30% and a 4-in. meter but 17% of the theoretical. In

[2]*Journal*, American Water Works Association, June, 1940.

the average city, over 95% of all meters are 5/8-in. in size and over 99% are 1-in. and less in size.

Free Water. There are various practices in municipal water plant operation with respect to the furnishing of so-called "free water". In some cities all water is billed and paid for; in others, water used by charitable institutions and other municipal departments is given a special discount; and in still others water is furnished for charitable and municipal uses without cost. It is, of course, obvious that there is no such thing as "free water". It is just a question as to who pays for it. In equity, all water should be sold at scheduled rates regardless of the purchaser. If those responsible for municipal policies decide to provide "free water", it should be metered in any event and the amount allowed free should be limited with a charge for all in excess. Better yet, all such water should be paid for at some rate even though materially lower than the scheduled rates. Public uses or "free water" usually take from 6 to 8 g.p.d. per capita.

Consumer Complaints. All complaints should be recorded as to time, cause, locality and corrective measures taken. Frequent review, grouped by causes and localities, has helped avert major dissatisfaction.

Conclusion. In conclusion, good management begins with good planning, requires a sound financial policy, alert, analytical administration of its own affairs and a knowledge of others, and the equitable allocation of the revenue requirements among the various classes of consumers.

ACCELERATED CLARIFICATION

BY FRANKLYN J. LAMMERS*

[*Read September 27, 1940.*]

Clarification, in the sense of preparing water for filtration by coagulation and removal of a maximum amount of suspended matter, is one of the most important functions of water treatment. The recent development of compact, high-rate equipment for lime softening has naturally focused attention on the possibilities of obtaining the same advantages in the coagulation and removal of turbidity, suspended matter, color and coagulable organic matter. This particular field is of especial significance in New England, where surface supplies are characteristically soft, comparatively low in turbidity and suspended matter, and frequently colored or otherwise evidencing organic matter.

Except when waters are highly colored, New England supplies ordinarily require low coagulant dosages and produce a rather light, voluminous floc. Successful results have been widely obtained with standard sedimentation basis of long retention time; in certain cases, these basins have been designed for the dual function of subsidence and reserve storage. Usually, conventional methods of applying coagulant are used, sometimes with initial rapid mixing for distribution, followed by special forms of slower mixing, for coagulation and development of a floc of maximum size.

Characteristically, a considerable amount of space, equipment and basin area are devoted to means for distribution of chemical. Special chambers are equipped with mechanical agitators or tangential inlets for centrifugal mixing. Paddles or extensive baffle construction are used for floc development. Rectangular or circular settling basins of at least two and commonly four or more hours' retention are provided for sedimentation—either with or without special sludge scraping and removal devices.

All variations of such plants follow a common principle of feeding the chemical coagulant to the water, mixing and then settling. Special adaptations and improvements in this series of process steps include proprietary equipment designs, many of which combine and

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coördinate the mixing and flocculation equipment with improved means of settling the precipitated coagulant and turbidity. One of these adaptations was the placement of a central agitated mixing zone inside a standard, concentric, circular clarifier. The clarifier was equipped with a central discharge sludge scraper, and provided results typical of the standard circular clarifier. The design offered mechanical advantage in integral construction for both coagulation and clarifying sections, plus some special blading in the mixing agitator. This had the purpose of retaining a portion of the floc in the mixing zone, to assist in the development of new precipitate.

Direct Upflow Basins. Another adaptation, still following the conventional steps of mixing chemicals and raw water, coagulating and then clarifying, directs the settling flow directly upward through a blanket of previously settled sludge. In one of these, the chemicals to be fed are first mixed with the raw water, which is then introduced at the bottom of a relatively high, cylindrical settling basin through a radial pipe system for distribution of the inlet water over the basin area. This type of upflow basin, using a premixing chamber for application and distribution of chemicals to the inlet water, has been well described in the literature (1) (2). The passage of the chemically dosed water up through a blanket of previously formed and settled sludge, affords opportunity for new, fine precipitate to be caught or screened out by adhesion, cohesion, or entanglements, with consequent improved clarification. Sludge collection and removal are simplified by opening the bottom distribution piping to waste momentarily and so sludging off the tank. Distribution of the influent over the tank area reduces short-circuiting, and the smaller area of sludge collection makes for economy of installation. Clarification rates of 1.5 in. per minute rise, or 0.9 g.p.m. per sq. ft. of plan area are recommended.

Basins Decreasing Flow Rate. Another design progressively slows the upward flow rate through a sludge blanket in a conical tank (3) (4). Chemicals are fed to the raw water as it passes downwardly through a central mixing chamber, the interior and bottom of which are swept by horizontal, rotating agitators. The partially treated water then turns upward through an annular, funnel-shaped clarification section in which a suspended sludge blanket is maintained.

The steps of chemical mixing and flocculation are carried out in one unit, followed by upward sludge-blanket filtration. The expanding

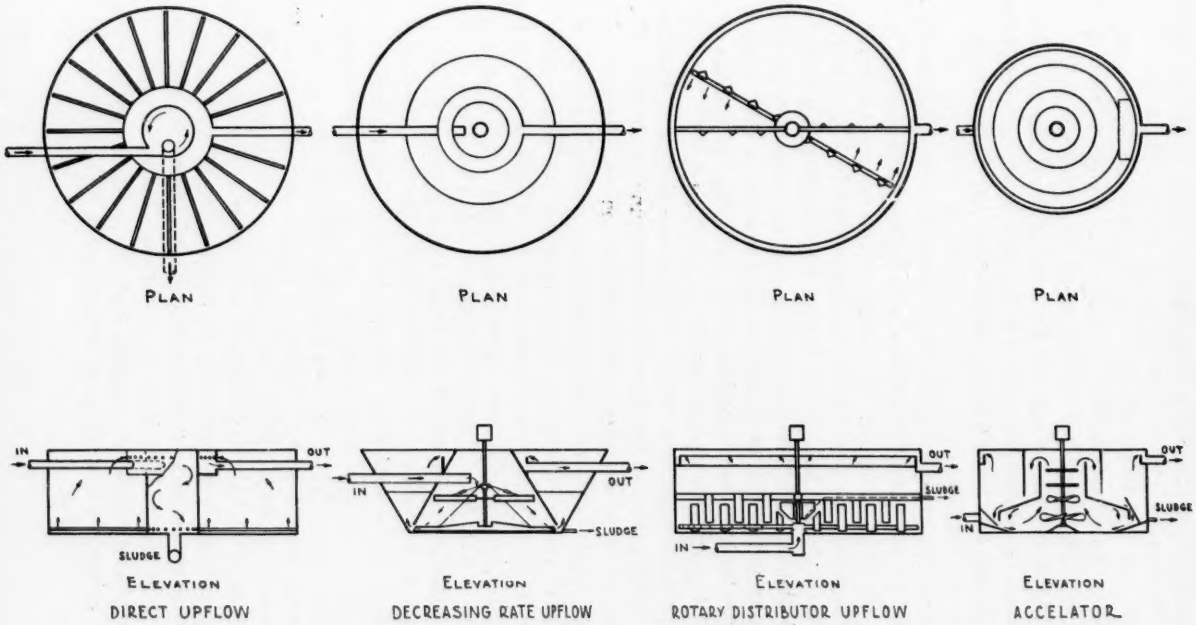

FIG. 1.—TYPES OF BASINS DESIGNED TO ACCELERATE CLARIFICATION.

cross-sectional area creates a progressively slower rising rate as water flows upward in the clarification zone, and affords opportunity for each floc particle to find its own level of maximum rise, according to its size and weight and the flow rate at that level. Sludge is removed from the bottom, either directly or into separate concentrators for further thickening. Clarification rates of the same order of around 1.5-in. rise per minute, or a maximum of 1.0 g.p.m. per sq. ft. are understood to hold, although published data on coagulation and clarification performance are not available.

Rotary Distributor Basin. More recently, there has been brought out a design using a cylindrical tank, bringing influent water into the bottom through a rotating distributor which provides chemical mixing and agitation in a suspended sludge blanket at the lower portion of the tank. Clarification occurs as the water progresses upward through the sludge blanket, and a central concentrator is provided for thickening and discharge of sludge. No clarification performance data are known to have been published, but operating rates in the range of 1.0 to 1.1 g.p.m. per sq. ft. have been mentioned.

It will be noted that these devices all are similar in following one general principle of adding chemical to incoming water and then going through the steps of mixing and flocculation and upward filtration through a sludge blanket. All provide improvement over operating results and space requirements of conventional, horizontal-flow basins, the characteristic operating rate being in the neighborhood of 1 g.p.m. per sq. ft. of basin. Separate flocculation zones are still present; and emphasis is placed on improved means of separating the solids, after such coagulation, by using sludge blankets of varying types.

Infilco Accelator. The Infilco Accelator, by contrast, is a development which completely departs from the conventional step of mixing chemical with raw water. It uses no sludge blanket and no preliminary flocculation of chemical and inlet water. It is based on early work by Infilco in sludge return during the period from 1919 to 1927, on which basis sludge return patents were issued to Behrman and Green (5). Although return of sludge from ordinary basins greatly hastened the completion of chemical and physical objectives, there has been only a limited utilization of sludge return. This was due largely to the difficulties of gathering sludge from the floor of conventional basins and returning it to the influent, without breaking up and losing its effectiveness in reclarification. Even in lime softening,

in which most of the sludge return work was done, it was difficult to handle the return of sludge without appreciable loss of its benefits. In working out means of sludge return without pumping or destructive handling, development work through 1935 gradually led to the realization that the former steps of mixing, flocculation and clarification could all be replaced by one simultaneous operation, the essential element of which was the controlled recirculation of large amounts—300 to 400% of influent water flow—of returned sludge slurry. By precharging the returning slurry of such large amounts with chemicals, *before* diffusing it with raw water, a remarkable difference in reaction results.

Samples dipped from such a slurry zone show completion of physical and chemical reactions in five minutes. At least 30 to 40 minutes are needed for comparable results with any modification of conventional mixing, flocculation and clarifying steps. Release of extremely clear water from the slurry zone is obtained almost immediately, a sharp line of demarcation being characteristic even when the slurry zone is in motion or agitation within the limits of viscous flow. As a consequence, clear water release at rates up to 2 and 3 g.p.m. per sq. ft. may be commercially practiced, and design is accordingly based on clear water release area, rather than any consideration of holding time or detention. In color removal, coagulation of turbidity, and lime softening, the Accelator utilizes the same principles of sludge recirculation, simultaneous precharging of chemical, and almost instantaneous clarification. The slurry zone, even under its conditions of forced agitation, functions as a distinct medium, maintaining its own characteristic surface and specific gravity. It even effects at the clear water—slurry zone interface an apparent surface tension of its own under viscous flow.

The exact physical chemistry of the Accelator slurry zone and its reaction is being given extensive study; the fundamental factors involved exert a complex, combined effect, which apparently warrants many channels of investigation. The effect, however, is subject to direct and ready application on various waters, and the design and principles of Accelator construction lend themselves to ready standardization.

Construction. The Accelator slurry zone occupies the entire lower and central area of the Accelator tank or basin, which is generally of simple cylindrical shape. Construction is adaptable to square

or other symmetrical shape. Propellers on a central, single shaft, designed for positive, forced circulation, recirculate slurry from the bottom, up through a central draft tube, then down over a hood which forms the roof of the lower recirculation zone. The area above the hood provides for clear water release and the slurry returns down around the periphery of the hood into the recirculation zone. Internal concentrators for sludge thickening are usually provided, discharging sludge either continuously or intermittently by either manual or automatic control, as desired. Clarified water is removed by peripheral launder, troughs or other takeoffs at the surface. The Accelator has no sludge blanket, nor any quiescent sludge or water columns in delicate hydraulic balance. The rate of recirculation is sufficiently high to effect complete and uniform distribution. The release of clear water, as has been mentioned, takes place from the slurry while it is flowing; velocities of 6 to 8 ft. per minute are often observable in the slurry surface. Due to the unique action of the slurry zone, Accelator floc is of greater than ordinary strength and toughness.

Positive Recirculation. Some of the best evidences of the completely distinct nature of Accelator action, are the relatively high recirculation velocities attained without injury to the unique Accelator floc. Propeller peripheral speeds of 6 to 8 ft. per second, and slurry velocities of 3 ft. per second or more are successfully maintained. By contrast, established practice with ordinary alum floc dictates a velocity of about 2 ft. per second peripheral speed, and water velocities of only 1 or 1.5 ft. per second. With such positive agitation, the short-circuiting or possible upset such as can occur with sludge blankets, are obviously a negligible factor in Accelators. Furthermore, higher concentrations of solids and overall specific gravities can be maintained in the slurry zone. This not only affords the greatest contact between water and slurry particles—an important element in the success of Accelator clarification—but permits correspondingly higher concentrations of solids in the thickened sludge discharge from the concentrators. Likewise, a greater ability to accept sudden increases in influent suspended matter content is realized; this is very important in water supplies that may be subject to sharp increases in turbidity or suspended matter. Since there is complete recirculation without any dead areas where sludge might settle and accumulate, there is no problem of sludge decomposition or odor. Of over 100 Accelators installed, for both clarification and softening, there are thirteen on

clarification alone at this writing. Six of these are municipal installations, the remaining seven being industrial.

Typical Installation. One of the largest installations is a 12-m.g.d. Accelator Clarifier and filter plant at the Scott Paper Company, Chester, Pa., a brief description of which may be pertinent. The installation comprises two Accelator Clarifier units, installed in con-

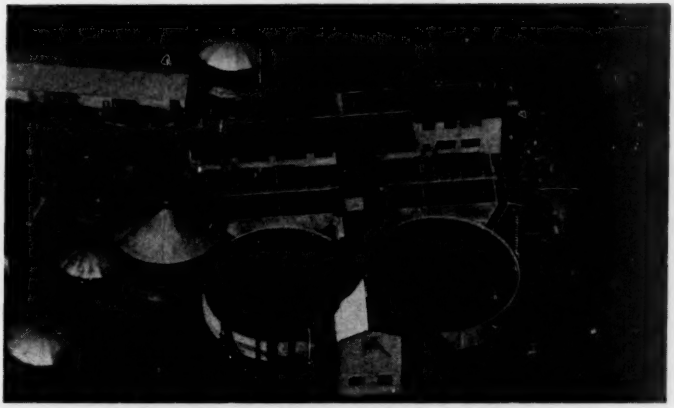

FIG. 2.—WATER PURIFICATION PLANT OF THE SCOTT PAPER COMPANY, CHESTER, PA.

crete basins 54 ft. in diameter and 18 ft. in center depth, each having a rated capacity of 6-m.g.d.; the necessary chemical feed and proportioning equipment for applying coagulant (aluminum sulphate) to the water; and eight concrete gravity Infilco filters with their attendant control equipment, each filter having a capacity of 1.5 m.g.d. The Accelators and filters are installed on a plot of land approximately 108 ft. in width and 120 ft. in length, a little less than 13,000 sq. ft. or about 0.3 acre. The saving in space made possible by the Accelator not only created a remarkable economy, but virtually saved the day for an improved water plant since the room required for a conventional system was not to be found. Such a conventional plant would have required 0.77 acre, or over 2½ times the area for the full plant. If comparisons are made exclusively on the relative areas of the clarification basins alone, savings are even more startling. A conventional four-hour basin would have had an area of about 27,000 sq. ft. The

two Accelators have a combined area of only 4,600 sq. ft., just 17%, or an 83% saving in space and extent of concrete work.

The Delaware River at Chester, containing appreciable industrial wastes and used as a ship channel, is subject to wide and extremely rapid variations in turbidity and organic content. Turbidities range from 50 to 500 p.p.m. and may increase several hundred parts per million within a matter of a few minutes, when a ship of deep draft passes close to the intake. The turbidity of the water leaving the Accelator Clarifiers, before filtration, is consistently less than 5 p.p.m, equal in clarity to many a so-called "clear" supply. Filtered, the water is brilliant and practically colorless. The active slurry zone of the Accelator provides an excellent shock absorber for the sudden increases in turbidity, which would upset results in ordinary installations. From available data on the amount of coagulant used in the conventional plant which the Accelator installation replaced, it was calculated that the average alum dosage was at least 2.5 grains per gallon (357 lb. per m.g.). The Accelator operation uses only 1.5 to 1.9 grains per gallon (214 to 272 lb. per m.g.) of aluminum sulphate on this highly contaminated, turbid water. These low dosages of coagulant demonstrate the efficiency in chemical utilization of the Accelator. The excellence of clarification is shown by filter runs averaging 70 to 80 hours, the filters being washed for approximately 5 minutes at 15 g.p.m. per sq. ft.

Each Accelator is normally rated at 6 m.g.d., or a rising rate of 1.83 g.p.m. per sq. ft. Operation is carried out at anywhere between this rate and 8.6 m.g.d., or 2.62 g.p.m. per sq. ft. without loss of clarity or operating efficiency.

Chemical Economy. The chemical economy of the Accelator is well illustrated by the Chester installation. Similar reductions in coagulant dosages are found in other cases, as compared with previous conventional installations. Municipal Accelators at Fairfield, Iowa, and Madison, Tenn., show reductions of 57 and 65%, respectively. Savings of this extent may not always be realized with waters containing only slight amounts of turbidity, or where the amount of coagulant is dictated by color removal considerations alone, but an expectation of using at least 25% less coagulant seems conservative. These savings are due not only to the greater effectiveness of the slurry-zone coagulation, but also to the fact that the chemicals and slurry are circulated and recirculated many times through the raw-

water flow. Obviously, all chemical particles are utilized, and none become uselessly buried in sludge and settled out.

To summarize: the Accelator provides unique means of:

1. Providing clarification at rates up to 2 and 3 g.p.m. per sq. ft.;
2. Delivering effluents, averaging well under 5 p.p.m. of turbidity;
3. Realizing chemical economies up to 25% or more;
4. Utilizing least space, saving up to 83% plan area;
5. Utilizing controlled sludge recirculation for:
   a. Prevention of short-circuiting;
   b. Elimination of sludge blanket;
   c. Avoiding sludge stagnation;
   d. Minimum sludge blowoff at highest solids concentration;
   e. Ability to handle sudden variations in load;
   f. Maximum flexibility and ease of operation.

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THE USEFUL LIFE OF IRON AND STEEL STANDPIPES

BY CHARLES W. SHERMAN

DISCUSSION BY A. V. RUGGLES*

[*Received September 28, 1940.*]

The information presented by Charles W. Sherman[1] on 111 iron and steel standpipes, mostly in New England, is a valuable contribution to the subject of life of water works structures, and credit is due the author for the care with which he has presented and analyzed the statistics. For the 111 standpipes he has obtained an average probable life of 45 years.

Table 1 brings out the following features of the record:

Total period	1870 to 1939—70 years
111 tanks installed	1870 to 1904—35 years
110 tanks installed	1879 to 1904—26 years
44 tanks retired	1887 to 1939—53 years

It is to be noted that the author limited his inquiries and studies to "structures which were at least 35 years old" and that the record consists wholly of early installations and includes no recent ones. Omitting the tank installed in 1870, the other 110 units were installed in the first 26 years of the 61-year period from 1879 to 1939.

Although the 67 tanks still in service are old tanks, perhaps virtually *the* old tanks surviving, it would be interesting to know if the author had particular reasons for believing that the units still in service are "nearing the end of their useful life", as mentioned in his first paragraph.

Statistical Computation of Life. The purpose of the studies made by the writer and presented in this discussion is to apply to this record methods customarily used in statistical computations of the probable average service life of physical property, for comparison with the 45-year result obtained by the author by rather general inspection.

Statistical methods based on the mathematics of probability pro-

*Public Service Commission, New York, N. Y.
[1]This Journal, **54**, 149 (1940).

TABLE 1—LIFE OF IRON AND STEEL STANDPIPES

Year	In Service on Jan. 1	Installed	Retired	Year	In Service on Jan. 1	Installed	Retired
1870	—	1	—	1907	101	—	1
1871	1	—	—	1908	100	—	1
1872	1	—	—	1909	99	—	—
1873	1	—	—	1910	99	—	—
1874	1	—	—	1911	99	—	—
1875	1	—	—	1912	99	—	3
1876	1	—	—	1913	96	—	—
1877	1	—	—	1914	96	—	—
1878	1	—	—	1915	96	—	4
1879	1	1	—	1916	92	—	—
1880	2	—	—	1917	92	—	—
1881	2	2	—	1918	92	—	—
1882	4	1	—	1919	92	—	1
1883	5	2	—	1920	91	—	—
1884	7	3	—	1921	91	—	1
1885	10	9	—	1922	90	—	1
1886	19	10	—	1923	89	—	—
1887	29	9	1	1924	89	—	1
1888	37	8	—	1925	88	—	1
1889	45	10	1	1926	87	—	1
1890	54	7	—	1927	86	—	2
1891	61	7	—	1928	84	—	3
1892	68	7	—	1929	81	—	1
1893	75	3	—	1930	80	—	3
1894	78	5	—	1931	77	—	2
1895	83	2	—	1932	75	—	—
1896	85	4	—	1933	75	—	—
1897	89	3	—	1934	75	—	—
1898	92	6	2	1935	75	—	2
1899	96	2	2	1936	73	—	—
1900	96	1	1	1937	73	—	—
1901	96	2	—	1938	73	—	2
1902	98	2	—	1939	71	—	4
1903	100	1	—	1940	67		
1904	101	3	2			—	—
1905	102	—	1	Total		111	44
1906	101	—	—				

duce more valuable results when applied to records of placements and retirements over a long period of time and of large numbers of like units, much larger numbers than in this standpipe record. Any result thus obtained from this record cannot be considered as valuable as one obtained from a complete history, if such could be compiled, of say a thousand tanks, including recent as well as earlier installations. Although recognizing that too much dependence cannot be placed on

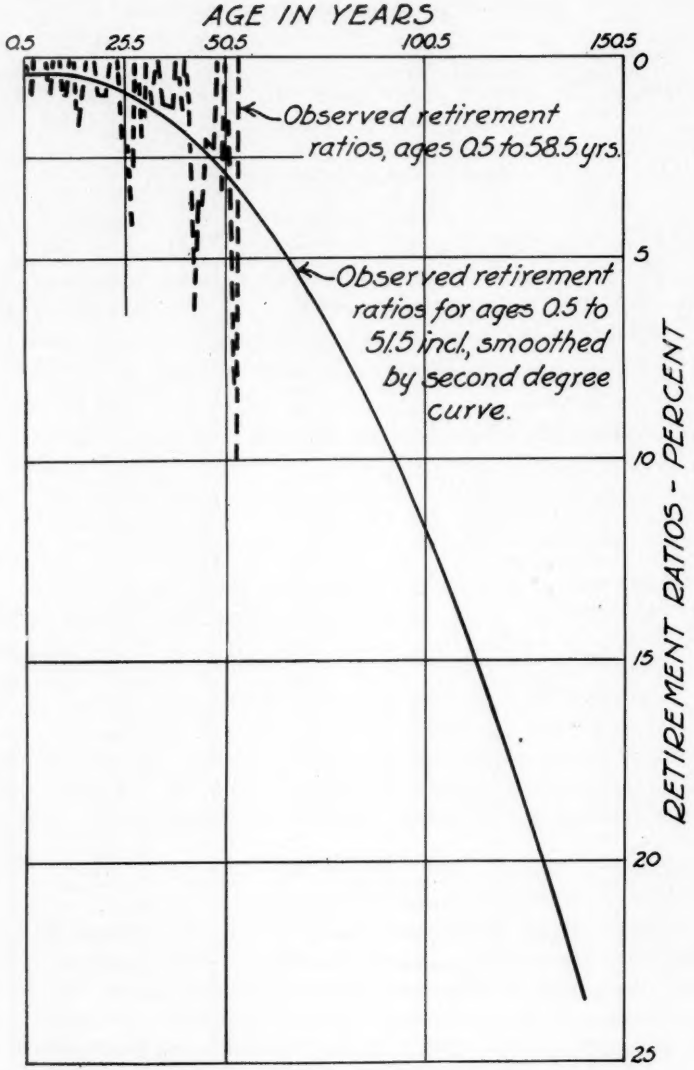

FIG. 1.—RETIREMENT RATIOS OF IRON AND STEEL STANDPIPES BY AGES.

TABLE 2—CALCULATION OF EXPOSURES AND RETIREMENTS
Note: All values used; only each tenth year shown.

Year	Tanks in Service Jan. 1	Tanks Retired During Year	Tanks Added / Tanks Retired	Age of Tanks Remaining Jan. 1 of Any Year: 0.5	1.5	5.5	10.5	20.5	30.5	40.5	50.5	58.5		
				Year of Construction of Tanks Remaining Jan. 1, 1887: 1886	1885	1881	1876	—	—	—	—	—		
1887	29	—	9	10	9	2	—							
	—	1	—	—	—	—	—							
1888	37	—	8	9	10	1	—							
	—	—	—	—	—	—	—							
1889	45	—	10	8	9	2	—							
		1	—	—	—	—	—							
1890	54	—	7	10	8	3	1							
		—	—	—	—	—	—							
1900	96	—	1	2	6	5	9	1						
		1	—	—	—	—	—	—						
1910	99	—	—	—	—	3	2	9						
		—	—	—	—	—	—	—						
1920	91	—	—	—	—	—	—	2	8					
		—	—	—	—	—	—	—	—					
1930	80	—	—	—	—	—	—	—	2	7				
		3	—	—	—	—	—	—	—	—				
1940	67	—	—	—	—	—	—	—	—	2	6	1		
		—	—	—	—	—	—	—	—	—	—	—		
Total Exposures	1887 to 1939		82	92	101	108	107	101	88	71	23	—	67	4610
Total Retirements		44	—	—	1	—	1	1	—	—	—	—	—	—

any value of average life obtained from this relatively small list of large units, restricted to early installations, these studies are offered as a discussion. There follows an explanation of the successive steps involved in the computation.

Table 1 presents a summary by the writer of placements and retirements for the 111 structures by *calendar years,* showing the 44 tanks retired and 67 still in service at the end of 1939. From the placements and retirements by calendar years it is customary, in statistical studies of the life of physical property, to prepare a table of placements and retirements by *ages,* and Table 2 is such a table, in which the totals at the bottom of the vertical columns are the total placements and total retirements for each year of age.

The ratio of total retirements to total exposures, or "observed retirement ratio", is given in Table 3 for each age by years from zero

TABLE 3—SUMMARY OF MORTALITY DATA FOR COMPUTATION OF LIFE TABLE
Note: Values have been computed for each year but are shown only for each tenth year

Age in Years	Exposures	Retirements	Observed Retirement Ratio	Observed Survival Ratio	Observed Life Table
0	82	0	0.0000	1.0000	1.0000
0.5	92	0	0.0000	1.0000	1.0000
10.5	107	1	0.0093	0.9907	0.9718
20.5	101	1	0.0099	0.9901	0.9173
30.5	88	0	0.0000	1.0000	0.7992
40.5	71	0	0.0000	1.0000	0.7421
50.5	23	0	0.0000	1.0000	0.5750
58.5	0	0	0.0000	1.0000	0.4852
					48.1730
					1.
					47.1730

to 58.5, the greatest age of any standpipe given. The observed life table which appears as the last column in Table 3 and as the observed survivor curve in Figure 2, results in an average service life of 47.17 years, close to the value of 45 years derived by the author.

It is evident that the observed retirement ratios (plotted in Figure 1) and the observed survivor curve are irregular; it is also to be borne in mind that a minor part, less than 40%, of the total placements has been retired. In cases such as this, students of the subject

of life of physical property have found it best to smooth, in accordance with the mathematics of probability, the records of retirements in the past, thereby establishing the best trend, based on the past, to be extended into the future and giving, from a projected and completed mathematically smoothed life table, the most probable value of *average* service life.

Some statisticians prefer to smooth mathematically the observed life table. The writer, however, prefers to smooth the observed retirement ratios and then from the smoothed retirement ratios compute the smoothed life table, using the methods developed by C. Beverly Benson, Principal Engineering Statistician, with the New York Public Service Commission.

Inspection of the observed retirement ratios shows a ratio of 0.1 for age 52.5 and a ratio of zero for greater ages. In applying the mathematical methods to these data, a better result is obtained by omitting the use of ages greater than 51.5, as the ratios beyond that

TABLE 4—COMPUTATION OF SMOOTHED LIFE TABLE AND AVERAGE SERVICE LIFE. *Note: Ages 0.5 to 51.5 years, inclusive, used; observed retirement ratios smoothed by second degree curve; only each tenth year shown.*

Age in Years	Retirement Ratios	*Smoothed* Survival Ratios	Life Table
0	0.0000	1.0000	1.0000
0.5	0.0040	0.9960	1.0000
10.5	0.0037	0.9963	0.9639
20.5	0.0060	0.9940	0.9209
30.5	0.0109	0.9891	0.8499
40.5	0.0183	0.9817	0.7379
50.5	0.0283	0.9717	0.5869
60.5	0.0409	0.9591	0.4161
70.5	0.0561	0.9439	0.2556
80.5	0.0739	0.9262	0.1321
90.5	0.0942	0.9058	0.0556
100.5	0.1171	0.8829	0.0185
110.5	0.1425	0.8575	0.0047
120.5	0.1706	0.8294	0.0009
130.5	0.2012	0.7988	0.0001
133.5	0.2109	0.7891	0.0001
			55.8971
			1.0000
		Average Service Life	54.8971

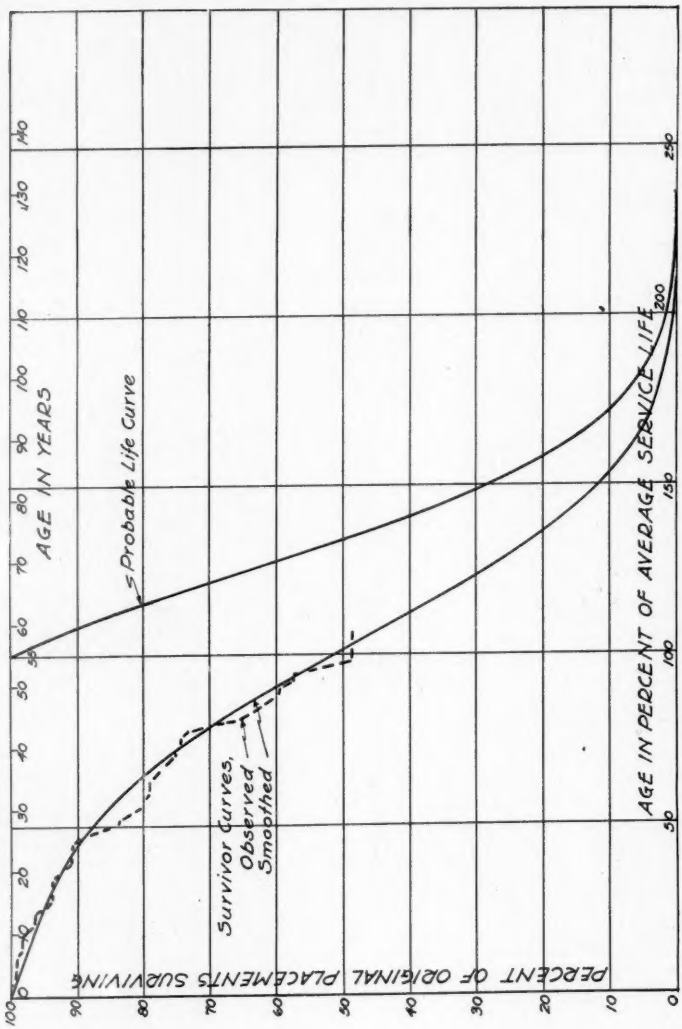

FIG. 2.—LIFE TABLE GENERATED BY SURVIVAL RATIO SECOND DEGREE CURVE. AVERAGE SERVICE LIFE INDICATED IS 54.9 YEARS.

age are not in line with the trend for the lower ages and if used have an undue effect on the results. In applying these methods to the standpipe data, the writer has employed a second degree curve for smoothing the observed retirement ratios.

Table 4 illustrates the computation of a smoothed life table and average service life, for ages 0.5 to 51.5 years, inclusive. Observed retirement ratios were smoothed by a second degree curve. Table 5 gives the life expectancy and probable life.

TABLE 5—COMPUTATION OF LIFE EXPECTANCY AND PROBABLE LIFE.
Note: Only each tenth of year is shown.

Age Interval, Years	Survivors at Beginning of Age Interval, %	Service During Age Interval, %	Remaining Service at Beginning of Age Interval, %—Years	Remaining Expectancy at Beginning of Age Interval, Years	Probable Total Life at Beginning of Age Interval, Years
0	100.0000	50.0000	5489.7694	54.8977	54.90
0.5	100.0000	99.7995	5439.7694	54.3977	54.90
10.5	96.3884	96.2087	4458.2725	46.2532	56.75
20.5	92.0934	91.8162	3514.3347	38.1605	58.66
30.5	84.9856	84.5229	2625.9174	30.8984	61.40
40.5	73.7894	73.1131	1828.4837	24.7798	65.28
50.5	58.6925	57.8606	1163.3995	19.8219	70.32
60.5	41.6114	40.7596	661.4147	15.8950	76.40
70.5	25.5608	24.8437	327.6801	12.8196	83.32
80.5	13.2076	12.7199	137.6135	10.4193	90.92
90.5	5.5649	5.3029	47.5336	8.5417	99.04
100.5	1.8500	1.7417	13.0671	7.0633	107.56
110.5	0.4684	0.4350	2.7570	5.8860	116.39
120.5	0.0869	0.0795	0.4272	4.9164	125.42
130.5	0.0113	0.0102	0.0440	3.8747	134.37
140.5	0.0010	0.0009	——	——	——
150.5	0.0001	0.0000	——	——	——
	5589.7733	5489.7733	——	——	——

The smoothed life table gives a probable average service life for the 111 standpipes of 54.9 years, and this value is believed by the writer to be a more probable average life than the 45 years obtained by the author. The 44 standpipes retired had an average life of 31.45 years. For the 67 standpipes still in use at the end of 1939 with an average age of 47.46 years, the writer's figures give an expectancy of

21.38 years and a probable life of 68.84 years. A weighted average is:

44 retired	x 31.45 years	= 1383.80	
67 still in use	x 68.84 years	= 4612.28	
111		5996.08	= 54.0 years
		111	

This is about the same as the value of 54.9 years obtained from the smoothed life table.

Iron versus Steel. It is always tempting to seek comparisons between iron and steel structures. In this record, corrosion from soil is not involved and relative effects on the metal of water and air are doubtless overshadowed in many cases by considerations of obsolescence due to inadequate capacity, elevation or other causes.

Table 1 is broken down in Table 6 to separate the iron structures

TABLE 6.—SEPARATION OF IRON AND STEEL STANDPIPES
I=Iron S=Steel U=Unknown T=Total

Year	In Service Jan. 1				Installed				Retired			
	I	S	U	T	I	S	U	T	I	S	U	T
1870	—	—	—	—	1	—	—	1	—	—	—	—
1871	1	—	—	1	—	—	—	—	—	—	—	—
1872	1	—	—	1	—	—	—	—	—	—	—	—
1873	1	—	—	1	—	—	—	—	—	—	—	—
1874	1	—	—	1	—	—	—	—	—	—	—	—
1875	1	—	—	1	—	—	—	—	—	—	—	—
1876	1	—	—	1	—	—	—	—	—	—	—	—
1877	1	—	—	1	—	—	—	—	—	—	—	—
1878	1	—	—	1	—	—	—	—	—	—	—	—
1879	1	—	—	1	1	—	—	1	—	—	—	—
1880	2	—	—	2	—	—	—	—	—	—	—	—
1881	2	—	—	2	2	—	—	2	—	—	—	—
1882	4	—	—	4	1	—	—	1	—	—	—	—
1883	5	—	—	5	2	—	—	2	—	—	—	—
1884	7	—	—	7	3	—	—	3	—	—	—	—
1885	10	—	—	10	4	3	2	9	—	—	—	—
1886	14	3	2	19	8	2	—	10	—	—	—	—
1887	22	5	2	29	4	3	2	9	1	—	—	1
1888	25	8	4	37	6	2	—	8	—	—	—	—
1889	31	10	4	45	8	2	—	10	—	1	—	1
1890	39	11	4	54	5	1	1	7	—	—	—	—
1891	44	12	5	61	4	1	2	7	—	—	—	—
1892	48	13	7	68	4	—	3	7	—	—	—	—
1893	52	13	10	75	2	1	—	3	—	—	—	—
1894	54	14	10	78	2	1	2	5	—	—	—	—
1895	56	15	12	83	2	—	—	2	—	—	—	—
1896	58	15	12	85	1	2	1	4	—	—	—	—
1897	59	17	13	89	1	2	—	3	—	—	—	—
1898	60	19	13	92	—	5	1	6	1	1	—	2

TABLE 6.—*Continued*

Year	In Service Jan. 1				Installed				Retired			
	I	S	U	T	I	S	U	T	I	S	U	T
1899	59	23	14	96	—	2	—	2	1	—	1	2
1900	58	25	13	96	—	—	1	1	1	—	—	1
1901	57	25	14	96	—	2	—	2	—	—	—	—
1902	57	27	14	98	1	1	—	2	—	—	—	—
1903	58	28	14	100	—	1	—	1	—	—	—	—
1904	58	29	14	101	—	3	—	3	1	1	—	2
1905	57	31	14	102	—	—	—	—	1	—	—	1
1906	56	31	14	101	—	—	—	—	—	—	—	—
1907	56	31	14	101	—	—	—	—	1	—	—	1
1908	55	31	14	100	—	—	—	—	1	—	—	1
1909	54	31	14	99	—	—	—	—	—	—	—	—
1910	54	31	14	99	—	—	—	—	—	—	—	—
1911	54	31	14	99	—	—	—	—	—	—	—	—
1912	54	31	14	99	—	—	—	—	3	—	—	3
1913	51	31	14	96	—	—	—	—	—	—	—	—
1914	51	31	14	96	—	—	—	—	—	—	—	—
1915	51	31	14	96	—	—	—	—	2	1	1	4
1916	49	30	13	92	—	—	—	—	—	—	—	—
1917	49	30	13	92	—	—	—	—	—	—	—	—
1918	49	30	13	92	—	—	—	—	—	—	—	—
1919	49	30	13	92	—	—	—	—	—	—	1	1
1920	49	30	12	91	—	—	—	—	—	—	—	—
1921	49	30	12	91	—	—	—	—	—	1	—	1
1922	49	29	12	90	—	—	—	—	1	—	—	1
1923	48	29	12	89	—	—	—	—	—	—	—	—
1924	48	29	12	89	—	—	—	—	—	—	1	1
1925	48	29	11	88	—	—	—	—	1	—	—	1
1926	47	29	11	87	—	—	—	—	1	—	—	1
1927	46	29	11	86	—	—	—	—	—	2	—	2
1928	46	27	11	84	—	—	—	—	3	—	—	3
1929	43	27	11	81	—	—	—	—	1	—	—	1
1930	42	27	11	80	—	—	—	—	3	—	—	3
1931	39	27	11	77	—	—	—	—	2	—	—	2
1932	37	27	11	75	—	—	—	—	—	—	—	—
1933	37	27	11	75	—	—	—	—	—	—	—	—
1934	37	27	11	75	—	—	—	—	—	—	—	—
1935	37	27	11	75	—	—	—	—	1	—	1	2
1936	36	27	10	73	—	—	—	—	—	—	—	—
1937	36	27	10	73	—	—	—	—	—	—	—	—
1938	36	27	10	73	—	—	—	—	2	—	—	2
1939	34	27	10	71	—	—	—	—	3	—	1	4
1940	31	27	9	67	—	—	—	—	—	—	—	—
					62	34	15	111	31	7	6	44

from the steel ones. There are only 34 steel standpipes, of which 7 have been retired, and no conclusion of great value can well be drawn from such figures. The following figures are however indicated:

Number of Standpipes in Use at End of 1939		Average Age, years	Expectancy, years	Probable Life, years
Iron	31	50.11	20.27	70.38
Steel	27	44.91	22.66	67.57
Unknown	9	45.94	22.06	68.00
Iron				
31 retired	—	average age	33.65	
31 still in use	—	average probable life	70.38	
62			52.015	average life
Steel				
7 retired	x	20.29 average age	= 142.03	
27 still in use	x	67.57 average probable life	= 1824.39	
34			1966.42	= 57.84 average life
			34	

CHARLES W. SHERMAN. Mr. Ruggles' analysis of the information on life of iron and steel standpipes in the JOURNAL for June, 1940, is interesting, especially as it indicates that computations on a statistical basis show a considerably longer period of useful life than that obtained by me by straight arithmetical averages, supplemented by a single assumption.

This assumption, that the average life of standpipes which are 35 or more years old and still in use, was arrived at by the "scientific" method of making two guesses and taking the average of them. Of course, if the guesses are unreasonable, the result should not be given weight. It seemed to me that it was reasonable to assume that the average future life of the standpipes 35 or more years old was not likely to exceed 10 years, or to be less than 5 years. The average is 7.5 years, and, neglecting fractions, I used 7 years.

I am inclined to be skeptical as to the value of the results of statistical computations from fragmentary data. There can be no doubt that, when the number of records is large and all of them are taken into consideration, results of great value can be obtained. But in this case, all existing standpipes of less than 35 years' age were arbitrarily left out of consideration. Moreover, I have little doubt that, instead of the 111 cases tabulated by me, there really are about

200 cases of standpipes in New England and New York which come in the classes reported.

I cannot bring myself to believe that even 1% of the standpipes which are built can continue in use for 100 or more years, as would be indicated by Mr. Ruggles' curves.

PROCEEDINGS

Fifty-Ninth Annual Convention

New York, N. Y.

September 24 to 27, 1940

The following is a synopsis of such parts of the proceedings of the Fifty-ninth Annual Convention as appear to be of value for the record.

The Fifty-ninth Annual Convention of the New England Water Works Association was held at the Hotel Commodore, New York, N. Y., September 24 to 27, 1940.

Tuesday, September 24

Morning Session

The convention was called to order at 10.30 A. M. by President Percy A. Shaw.

Administrative Reports

The Annual Reports of the Secretary, Treasurer, Editor and Finance Committee were presented (see p. 000), accepted and ordered placed on file.

The Report of the Committee on Investments was read by Leland G. Carlton, Chairman, accepted and ordered placed on file (see p. 000).

The Annual Report of the Legislative Committee was read by Arthur C. King, Chairman, accepted and ordered placed on file (see p. 000).

The Annual Report of the Committee on Committees was read by Warren J. Scott, Chairman, accepted and ordered placed on file (see p. 000).

Secretary Gifford announced the election by the Executive Committee of the following members:

Members: Robert Charles Thompson, Superintendent, Water & Aqueduct Co., Rockville, Conn.; Dennis F. Sweeney, Water Registrar, Springfield, Mass.; Charles Morey, Superintendent, Water Department, North Conway, N. H.; Malcolm Jesse Quimby, Civil Engineer, Sharon, Mass.; Otis Swift Tolman, Superintendent, Water

Department, Sharon, Mass.; Edward L. Tracy, Sanitary Engineer, Vermont State Department of Health, Burlington, Vt.; Francis Mitchell Hennesssy, Superintendent, Water Department, Northampton, Mass.; Albert E. Brown, Water Commissioner, Somerset, Mass.; Nat Sidney Stevens, Superintendent of Streets and Water, Portsmouth, N. H.; Allan Graham Davenport, General Manager, Water Company, Jamestown, R. I.; Arthur V. Ruggles, Civil Engineer, New York, N. Y. (reinstated); William J. Orchard, General Manager, Wallace & Tiernan Co., Newark, N. J.; Richard H. Smith, Chairman, Water Commissioners, Hamilton, Mass.

Associates: Rusta Restor Corporation, Fremont, O.; Electro Rust-Proofing Co., Dayton, O.; Continental Pipe Manufacturing Co., Inc., New York, N. Y.; The Gorman-Rupp Co., Mansfield, O.; Paint Engineers, Inc., Hawthorne, N. J.; Flexible (Underground) Pipe Cleaning Co., Los Angeles, Cal.; Omega Machine Company, Kansas City, Mo.; The Bristol Company, Waterbury, Conn.

Closing of Polls and Appointment of Tellers

The President declared the polls closed and appointed Horace L. Clark and Mark F. Crocker as tellers to count the ballots.

Luncheon Session

The Luncheon Meeting was addressed by Rufus McGahan, Deputy Mayor and Commissioner, Board of Water Supply, New York, N. Y., who brought the greetings of His Honor, Mayor Fiorello H. LaGuardia, Mayor of the City of New York.

Mr. E. Sherman Chase read the following communication from Mr. John Bowman, President of the Institution of Water Engineers and City Engineer of Edinburgh, Scotland:

"As President of the Institution of Water Engineers I would like to send the fraternal greetings of our Institution to the members of the New England Water Works Association when they meet in conference in New York at the end of this month.

"In the paper on British Water Works Practice which was presented to your conference last year, I referred to air raid precautions to be adopted by water works undertakings in the event of war. Since then war has broken out, and after a year the struggle has become narrowed down to one between the British Empire and the Axis Powers.

"Now that the enemy has disposed of other opponents it leaves them free to concentrate their full strength upon our Empire and particularly upon Great Britain. Air attacks are being made with persistence and are likely to increase

in intensity. The public services are now called upon to face conditions of extreme warfare. From the results so far achieved by the enemy we may view the future with equanimity. Even where the attacks have been greatest, the public services have functioned and civil life has been almost on normal lines. For the first time the enemy air force has had to cope with an opposition which has inflicted upon it appalling losses. We are not only successfully overcoming air attacks in this country but are carrying effectively the war in the air into the very heart of Germany itself and with ever increasing momentum.

"On the sea the might of the British Navy protects us from destruction and will continue to do so until the forces against us are obliterated. The time will come when the British Army will take its part in the great struggle. We fight the forces of unrighteousness, evil and tyranny and in the end we will, by the help of God, be victorious.

"Nothing has been so stimulating to our country in its struggle as the knowledge that behind it is the approval and the moral and material support which has come so generously from the United States of America. Your Association represents a certain section of this great nation and the Institution of Water Engineers is a representative British institution. Let me, therefore, as President of our Institution, convey to your Association our feelings of good will and brotherliness. Our two bodies have common aims in furthering our knowledge so that a great source of Nature may be used in the service of man. So may our common aims be extended in every direction and the British Empire become linked with the United States in those common aims which have for their object the enjoyment of peace and freedom by all the peoples of the world."

MR. CHASE. In view of the terrific responsibility and dangers with which our water works colleagues in England, Scotland and Ireland are faced, the following resolution is offered for adoption by our Association—your committee consisting of President Shaw, Vice-President Carlton, and myself:

WHEREAS, the New England Water Works Association has entered into an agreement with the Institution of Water Engineers for the reciprocal exchange of outstanding papers for the fostering of good will between the water works fraternities of the United States and Great Britain, and

WHEREAS, the members of the Institution of Water Engineers are sorely beset by ruthless adversaries and are operating their water works in the face of unprecedented difficulties and danger,

BE IT RESOLVED, that we of the New England Water Works Association, assembled in annual convention in New York City, on September 24, 1940, extend to the Institution of Water Engineers our most sincere sympathy, with the fervent hope that a righteous victory will soon permit its members to return to the normal activities of peace.

This resolution was unanimously adopted.

Award of the Dexter Brackett Memorial Medal

Harry U. Fuller. I have a very pleasant task to perform today in speaking for the Committee on the Award of the Dexter Brackett Memorial Medal. That committee consists of Harold W. Griswold of Hartford, Conn., Harry Manson of Lebanon, N. H., and myself.

The Journal for last year was full of excellent and meritorious papers, and your committee had a difficult job to pick out one paper which they thought came the nearest to fulfilling the ideas and the spirit of Dexter Brackett. It was stated in the setting up of this medal that the author of the most meritorious paper each year, bearing in mind its applicability to general water works problems, should be presented with the medal.

Finally it was decided that the paper by George A. Sampson, entitled "The Cost of Small Surface Water Supplies in New England," met the requirements and that Mr. Sampson should receive the Memorial Medal. This paper is of great practical value to a wide variety of water works men. It deals with prices, with costs, with details of the construction of water works, and it gives clues as to how these prices of today, by the use of an index, can be applied to other years in the years to come.

George Sampson is well known to you all. He is a consulting engineer. He has recently been President of this Association. I shall not attempt to tell you of his many good qualities, but you will find scattered around this country first-class, successful water works running to testify to his abilities.

It gives me pleasure to present to you, George A. Sampson, the Dexter Brackett Memorial Medal for the most meritorious paper published in the Journal in the year 1939.

George A. Sampson. Mr. President, Members of the New England Water Works Association: When I was informed that I was to receive this award I experienced two different emotions. One was surprise, and I am still surprised that my paper should warrant this award. The other was pleasure, especially as it was my privilege to live almost directly across the street from Mr. Brackett from 1910 until his death in 1915, and I can assure you that during that period the contacts that I had with him were helpful to a young engineer. Mr. Brackett was that type of man. At Marston's Restaurant in Boston

there was a table of water works engineers, where Dexter Brackett, Charles W. Sherman, William T. Barnes, and others, members of the New England Water Works Association, met for luncheon, and you can rest assured that I listened with a great deal of interest and much profit to the discussions there on water works problems. Those were the good old days when a real chowder, with plenty of fish or lobster or clams, and other ingredients, came to fifteen cents, and a piece of pie, which was a quarter of a man-sized pie, ten cents, and a cup of coffee or a glass of milk five cents. There you had good comradeship and enjoyed excellent food all for thirty cents. You had all those attractions, not to mention the dark-eyed waitress, for thirty cents.

I am greatly pleased to receive this medal, particularly as I knew Mr. Brackett and appreciated his profound knowledge of water works and his many sterling qualities as a man. I thank you all very much.

Afternoon Session

A paper "The Supervision of Dams and Reservoirs in Connecticut," was read by Clarence M. Blair, Consulting Engineer, New Haven, Conn. The paper was discussed by Thomas H. Wiggin and William W. Brush.

A paper "HI-CO—A New Tar Coating to Maintain High Coefficient of Flow," was read by H. J. Billings, Research Director, Arthur D. Little, Inc., Cambridge, Mass. L. J. Bevan, Roger W. Esty, Edwin J. Lane, James E. Gibson, Donald C. Calderwood, George F. Weighardt, William W. Brush, Leonard P. Wood, and Linn H. Enslow took part in the discussion.

The Second Progress Report of the Committee on Rainfall and Yield of Drainage Areas was presented by Francis H. Kingsbury for Arthur D. Weston, Chairman.

A paper "The Activities of the Works Progress Administration in the Field of Water Supply and Distribution," was read by John P. Hallihan, Engineering Division, W.P.A., Federal Works Agency, Washington, D. C. D. M. Sullivan, Samuel E. Killam, Linn H. Enslow, William W. Brush, and William A. MacKenzie took part in the discussion.

WEDNESDAY, SEPTEMBER 25

Morning Session

President Shaw in the chair.

A Progress Report of the Committee on Meter Specifications was read by Richard H. Ellis, Chairman.

A paper "The Construction of the Delaware Aqueduct," was read by Roger W. Armstrong, Deputy Chief Engineer, Board of Water Supply, City of New York. Karl R. Kennison, Leonard P. Wood, and James F. Sanborn took part in the discussion.

A paper "Sanitation of the Construction Areas on the Delaware Aqueduct," was read by Frank A. Marston, Consulting Engineer on Staff of Chief Engineer, Board of Water Supply, City of New York; Partner, Metcalf & Eddy, Engineers, Boston, Mass. The paper was discussed by Charles R. Cox.

THURSDAY, SEPTEMBER 26

Morning Session

President Shaw in the chair.

A Progress Report of the Committee on Standardization of Pipe Flanges and Fittings and the Report of the Committee on Specifications for Cast Iron Pipe and Special Castings were read by William R. Conard, Chairman. On motion, duly seconded, the Specifications for Cast Iron Pipe and Special Castings adopted by the American Water Works Association were adopted by the Association.

A Report of the Committee on Hydrant Specifications was read by Harry U. Fuller. On motion, duly seconded, the Specifications for Hydrants adopted by the American Water Works Association were adopted by the Association.

A Progress Report of the Committee on Emergency Procedures was presented and discussed by Donald C. Calderwood, Chairman.

A paper "Water Supplies during Time of War," was read by F. F. Longley, Lock Joint Pipe Company, Ampere, N. J. The discussion was participated in by Arthur H. Pratt, W. A. Hardenbergh, E. J. Cleary, Thomas H. Wiggin, F. W. Scheidenhelm, A. E. Griffin, E. Sherman Chase, Warren J. Scott, Francis H. Kingsbury, Norman J. Howard, H. S. Hutton, and Frank E. Hale.

Afternoon Session

Vice-President Leland G. Carlton in the chair.

A paper "Bacteriological and Field Studies of Conditions in Water Distribution Systems," was read by Warren J. Scott, Director, Bureau

of Sanitary Engineering, State Department of Health, Hartford, Conn. Stanley T. Barker, Francis H. Kingsbury, George Norcom, Charles R. Cox, Linn H. Enslow, E. Sherman Chase, Norman J. Howard, and Thomas M. Riddick took part in the discussion.

Robert Spurr Weston submitted a Progress Report of the Committee on Water Works Education.

A paper "Effect of 1939 Drought on Water Supply Progress in New Jersey," was read by Charles H. Capen, Civil and Sanitary Engineer, West Orange, N. J. William W. Brush, Leland G. Carlton, and Henry T. Gidley took part in the discussion.

E. SHERMAN CHASE presented the following resolution:

WHEREAS the problem of water works protection against sabotage and possible wartime damage is now an acute problem confronting the managements of water works,

BE IT RESOLVED that it is the firm belief of this Association that water works budgets for the coming year should be adequate for such protective measures as may be required in the case of each particular municipality.

Upon motion, duly seconded, it was VOTED that this resolution be adopted.

A paper "Problems of Municipal Water Works Management," was read by Louis R. Howson, Consulting Engineer, Alvord Burdick and Howson, Engineers, Chicago.

A paper "Filter Operation and Maintenance," was read by John R. Baylis, Physical Chemist, Bureau of Engineering, City of Chicago.

FRIDAY, SEPTEMBER 27

Morning Session

President Shaw in the chair.

REPORT OF TELLERS OF ELECTION

Number of ballots cast	192
Number of ballots counted	191
For President, Leland G. Carlton	189
For Vice-President, Harold L. Brigham	191
For Director, Harold W. Griswold	190
For Treasurer, Abel Reynolds	190
Blanks	1

(Signed) MARK F. CROCKER
HORACE L. CLARK, *Chairman*

PRESIDENTIAL ADDRESS

The Place of Water Works Men

By Retiring President Percy A. Shaw

We are spending four days here intent on learning how to do our work better. Apparently we realize the importance of doing better work. Do we realize the importance of the work we do? Do those we serve realize the importance of our service? If they do not, how can we expect the water works man to have the recognition, the living conditions, that will enable him to do his best work and attract to this work able men?

Who in your city delivers to each of his customers at least a ton of produce every day in the year? Only the water works man! Who delivers a ton of material inside his customers' premises for from two to six cents a ton? Only the water works man! If you serve a city of 100,000 people you deliver direct to the consumer at least 50 million pounds, or 25,000 tons of water every day. All the trucks in your city couldn't bring that water into town, much less distribute it. This is the material end of our business! We distribute more bulk and weight to our customers than anyone else in our towns and cities, —much more. But, you say, we do it easily, simply, cheaply. Sure we do; because water works men in time past thought out and developed the pipe system of delivery and, more recently, efficient pumps and water conditioning plants. Remember that there are countries where all the water available to the public is peddled from men's backs, in goat skins. In a material sense we perform a vast service.

But we are not expected to deliver just water, any old water. To be satisfactory to the present-day public a water supply should be bacterially pure, soft, clear, colorless, odorless, cool, ample in quantity, certain of delivery, cheap and at a satisfactory pressure. That is a large order; few of us can meet it in every respect. But the water works man is responsible for each item of these specifications and nearly all of these requirements are, or may be, influenced both by the operating policies followed and by the day-to-day care in adhering to those policies.

Purity we obtain by care of our watersheds, by filtration and

disinfection. If the water is hard, we soften it. By long storage or by means of conditioning plants we improve its clearness, color and odor. Temperature we can affect but little. By efficient pumps we maintain the required pressure. By constant development of supplies we keep up with the ever increasing demand; and by the use of quality materials, by duplication of pipe lines and equipment and by training of personnel we maintain the all important certainty of supply.

Called the "Superintendent" the man in charge of a municipal water works is in fact the general manager. He is responsible for finances, budgets, collections, and purchasing. He is also responsible for the selection and operation of equipment and machines of many kinds, used for transportation, pumping, construction and purification. Like any manager he must handle his help. Last and by no means least he must handle the public, who are both his customers and his bosses.

The water supply of a town is the most important element in the citizens' health, domestic convenience, and protection from fire, and is important to many industrial operations.

Water is the commodity essential to the modern city. If the water supply is stopped, the city may become uninhabitable; if the water supply is polluted, pestilence, one of the dreaded "Four Horsmen," will soon ride through the community. Clean safe water under pressure makes the modern city possible, the village comfortable. Great is the responsibility of the water works man!

Two things we want our public to realize,—no, three; first that our work is important, second that we are doing our work well, and third that we are keenly anxious to do it better. When you go home I want you to go in the full realization that no man in your city performs a greater service for that city than you do; that you and your service are as important to that town's or city's prosperity, health and comfort as any man or any service in it. In that realization you will serve your city better and because of it that service is sure to be better appreciated.

* * * *

The President then introduced the President-Elect, Leland G. Carlton.

MR. CARLTON. Thank you, Mr. President and Members. I am very grateful for this honor that has been given me, and it certainly is an honor to be chosen to head an organization such as the New

England Water Works Association,—one that has built up and maintained such a marvelous record for itself through all these years. I assure you that I shall give my best efforts in an endeavor to maintain that record. I appreciate the confidence you have in me. I thank you.

On motion, duly seconded, it was VOTED to extend a most hearty vote of thanks to the Water and Sewage Works Manufacturers Association for its share in making the Fifty-ninth Convention one of the outstanding conventions of the New England Water Works Association, and that special thanks go to Mrs. W. W. Brush for her able and untiring labors as chairman of the Ladies Entertainment Committee.

Superintendents' Session

Harold W. Griswold, Deputy Chief Engineer, Water Bureau, Hartford Metropolitan District Commission, Hartford, Connecticut, presiding.

A paper "Four Disasters," was read by Henry T. Gidley, Treasurer and Superintendent, Fairhaven Water Company, Fairhaven, Mass.

A paper "The Milford Water Company Considers Cathodic Protection," was read by H. M. Goff, Superintendent, Milford Water Company, Milford, Mass. William W. Brush, Frank M. Tobin, Sidney S. Anthony, Warren J. Scott, Robert Spurr Weston, E. T. Cranch, Linn H. Enslow, and Donald C. Calderwood took part in the discussion.

A paper "What Is the National Plumbing Laboratory?" was read by M. W. Cowles, Health Officer, Hackensack Water Company, New Milford, N. J. The paper was discussed by Horace L. Clark, Henry T. Hotchkiss, E. T. Cranch, Percy S. Wilson, Henry E. Halpin, and Arthur Herberger.

A paper "Coöperation of Fire and Water Departments," was read by R. C. Dennett, Engineer, Committee on Fire Prevention and Engineering Standards, National Board of Fire Underwriters, New York City. Percy S. Wilson, Harold W. Griswold, Roger G. Oakman, E. T. Cranch, Richard H. Ellis, Donald C. Calderwood, Hugh McLean, William W. Brush, Harry U. Fuller, and Linn H. Enslow took part in the discussion.

A paper "Promoting Tax Payer Interest in Water Supply," prepared by C. Schwarzler, The Foxboro Company, Foxboro, Mass., was read, in the absence of Mr. Schwarzler, by Secretary Gifford.

Chemists' Session

F. Wellington Gilcrease, Associate Sanitary Chemist, Division of Laboratories, New York State Department of Health, Albany, N. Y., presiding.

The Report of the Committee on Quality Tolerances of Water for Industrial Uses was read by Stuart Coburn for Edward W. Moore, Chairman, and upon motion, duly seconded, was accepted by the Association as a progress report. [See this JOURNAL, 44, 261 (1940).]

A paper "Accelerated Clarification," was read by Franklyn J. Lammers, Assistant Technical Director, International Filter Company, Chicago. R. H. Early, Mr. Beaner of the Permutit Company of New York City, and Henry T. Hotchkiss took part in the discussion.

A paper "Sanitation and Purification of New York City's Water Supplies," was read by Frank E. Hale, Director of Laboratories, Bureau of Water Supply, City of New York. Charles R. Cox, Thomas H. Wiggin, John R. Baylis, and Mr. Muddiman, chemist for the Kingston, N. Y., Water Supply, took part in the discussion.

Mr. Lee T. Purcell, Sanitary Engineer, North Jersey District Water Supply Commission, Wanaque, N. J., showed pictures of the Wanaque Reservoir Supply.

(Adjourned)

Annual Report of the Secretary

Mr. President and Gentlemen of the New England Water Works Association: The Secretary submits herewith the following report of the changes in membership during the past fiscal year, and the general condition of the Association.

The present membership is 801, constituted as follows: 9 Honorary Members, 659 Members, 1 Junior Member, 111 Associate Members and 21 Corporate Members. The detailed changes are as follows:

MEMBERSHIP

September 1, 1939.	Honorary Members, Total		11		
	Withdrawals:				
	Died	2	2	9	
	Elected	0		0	9
September 1, 1939.	Members, Total		647		
	Withdrawals:				
	Resigned	8			
	Died	13			
	Dropped by Executive Committee	1	22	625	
	Elected:				
	September, 1939	8			
	November, 1939	5			
	December, 1939	3			
	January, 1940	6			
	March, 1940	4			
	April, 1940	3			
	May, 1940	2		31	
	Reinstated:				
	September, 1939	1			
	January, 1940	1		2	
	Transferred from Junior Membership:				
	September, 1939	1		1	659
September 1, 1939.	Juniors, Total		2		

	Withdrawals:				
	Transferred to Members	1	1	1	
	Elected	0		0	1
September 1, 1939.	Associates, Total		110		
	Withdrawals:				
	Resigned	1			
	Dropped by Executive Committee	2	3	107	
	Elected:				
	September, 1939	2			
	Reinstated:				
	September, 1939	2		4	111
September 1, 1939.	Corporates, Total		21		
	Withdrawals	0			
	Elected	0	0		21
September 1, 1940.	Total Membership				801
September 1, 1939.	Total Membership				791
	Net Gain				10

ELECTIONS.

Members.

September 12, 1939. John J. Baffa (Transferred from Junior Membership), Harold W. Baker (Reinstated), Sydney C. Beane, Samuel W. Bowers, Clifford O. Duval, Harry E. Jordan, Théo. J. Lafrenière, Frand D. Lord, Walter J. Shea and Leonard W. Trager. (10)

November 16, 1939. William Francis Herlihy, Thomas Stimpson Lawrence, John Howland Robinson, Lazarus Rubin and Sidney Albert Thompson. (5)

December 21, 1939. James Elliott Hale, John Edward McDonald and Russell Starck. (3)

January 18, 1940. Frederick F. Aldridge, Madison Hancock Goff, Vincent M. Hynes, Scott Keith (Reinstated), William Seward Mariner, Frank Anthony Nicoli and Frederick C. Walton. (7)

March 21, 1940. John W. Draper, Samuel E. Eldridge, John M. Littlefield and Albert H. Pye. (4)

April 25, 1940. Otto Hagmann, Thomas Hart and Clifford I. Tripp. (3)

May 23, 1940. Lester B. Hull and Charles R. Moore. (2)

Associates.

September 12, 1939. Boston Edison Company, Joseph Dixon Crucible Co. (Reinstated), Fred A. Houdlette & Son, Inc. (Reinstated) and Lead Industries Association. (4)

WITHDRAWALS

Honorary Members.

Died: Thaddeus Merriman and Robert J. Thomas. (2)

Members.

Resigned: John D. Annis, Everett M. Battey, Wilbert C. Hardy, Paul Lanham, John B. Moore, William J. McCarthy, Kenneth E. Packard and Thomas B. Ray. (8)

Died: William F. Codd, Guy C. Emerson, Charles H. Eglee, Charles R. Felton, Stephen DeM. Gage, William C. Hawley, Willard B. Marden, Josiah S. Maxcy, Alexander Potter, Walter E. Rundlett, Walter E. Spear, A. H. Tillson and George E. Waters. (13)

Dropped by Executive Committee: John W. Mulcahy. (1)

Juniors.

Transferred to Membership: John J. Baffa. (1)

Associates.

Resigned: Hauck Manufacturing Company. (1)

Dropped by Executive Committee: A. W. Chesterton Company and Syntron Company. (2)

RECEIPTS FOR THE FISCAL YEAR SEPTEMBER 1, 1939 TO SEPTEMBER 1, 1940.

Entrance Fees			$ 88.00
Annual Dues:			
Juniors	$ 3.00		
Members	2,346.00		
Corporates	150.00		
Associates	1,280.00	$ 3,779.00	
Fractional Dues:			
Members	$ 69.00	69.00	
Past Dues:			
Members	$ 186.00		
Associates	100.00	286.00	
1940-1941 Dues:			
Members	$ 960.00		
Corporates	40.00		
Associates	1,040.00	2,040.00	
Total Dues			$6,174.00
Dividends and Interests			378.53
Advertisements			3,748.60
Subscriptions			505.15
Journals			55.14

Reprints		142.85
Sundries		67.73
Total Receipts		$11,160.00
There is due the Association:		
Entrance Fees	$ 9.00	
Dues	764.50	
Advertisements	143.00	
Journals	95.00	$ 1,011.50
Total		$12,171.50

Respectfully submitted.

(Signed) FRANK J. GIFFORD, *Secretary.*

Annual Report of the Treasurer

The President and Members of the New England Water Works Association:

I herewith submit the annual report of the Treasurer of the New England Water Works Association for the year ended August 31, 1940:

Statement of Cash Receipts and Disbursements

General Fund

For the Year ended August 31, 1940

Receipts			
Initiation Fees		$ 88.00	
Dues, 1939-1940 and Prior Years	$ 4,134.00		
Paid in Advance	2,040.00	6,174.00	
Interest		378.53	
From Publication of Journal			
Advertisements	3,748.60		
Subscriptions	505.15		
Sale of Journal	55.14		
Sale of Reprints	142.85		
Sale of Halftones, Electros, etc.	13.09	4,464.83	
Miscellaneous			
Membership Certificates	24.15		
Membership Lists	3.00		
Sundry	5.76	32.91	
Total Receipts			$11,138.27
Disbursements			
Publication of Journal			
Printing	2,377.75		
Plates	421.65		
Reporting	89.86		
Reprints	107.81		
Stationery and Postage	129.26		
Editor's Salary	500.00		
Sundry	220.13	3,346.46	
Office and General			
Certificates of Membership	11.74		
Medals	30.30		

Secretary's Salary	400.00		
Assistant Secretary's Salary	1,616.50		
Secretary's Expense	94.42		
Treasurer's Salary	100.00		
Treasurer's Bond	12.50		
Printing, Postage and Stationery	199.92		
Office Supplies and Expense	182.14		
Office Rent	1,200.00		
Electricity	59.99		
Telephone and Telegraph	154.90		
Audit	65.00		
Sundry	165.44	4,292.85	
Meetings and Committees			
Badges	35.88		
Water Works School	100.00		
Printing, Postage and Stationery	638.13		
Convention Expense	379.67		
President's Expense	53.30		
Sundry Expense	90.39	1,297.37	
Total Disbursements			9,436.68
Excess of Receipts over Disbursements			1,701.59
Balance, General Cash, August 31, 1939		4,115.39	
Less Transferred to Invested Funds		1,688.75	2,426.64
Balance, General Cash, August 31, 1940			
Represented by			
Cash in First National Bank of Boston		4,078.23	
Cash in Office		50.00	
			$ 4,128.23

STATEMENT OF ASSETS AND FUNDS

As at August 31, 1940

Assets

Cash in Banks, Invested Funds		
City Five Cents Savings Bank, Haverhill, Massachusetts	$ 2,000.00	
Farmers and Mechanics Savings Bank, Framingham, Massachusetts	2,068.46	
Franklin Savings Bank, Boston, Massachusetts	2,000.00	
Haverhill Savings Bank, Haverhill, Massachusetts	2,000.00	
Home Savings Bank, Boston, Massachusetts	2,000.00	
Mechanics Savings Bank, Reading, Massachusetts	2,000.00	
Pentucket Savings Bank, Haverhill, Massachusetts	2,000.00	
The People's Savings Bank, Worcester Massachusetts	2,000.00	

Suffolk Savings Bank, Boston, Massachusetts	2,000.00	
Total Invested Cash		18,068.46
General Fund		
Cash, First National Bank of Boston	4,078.23	
In Office	50.00	
	4,128.23	
Furniture and Fixtures	1,180.00	5,308.23
		$23,376.69

Funds

Invested Funds		$18,068.46
General Fund	5,295.39	
Balance Fund, August 31, 1939		
Deduct Transferred to Invested Funds (deposited in Home Savings Bank)	1,688.75	
	3,606.64	
Add Excess of Receipts over Disbursements	1,701.59	
Balance, August 31, 1940		5,308.23
		$23,376.69

Note: This statement is prepared on a cash basis and does not reflect the following:

Accounts Receivable, Dues		$ 773.50
Due on Account of Advertising and Other Miscellaneous Charges		238.00
		1,011.50
Dues Paid in Advance		$ 2,040.00

No depreciation has been taken on Furniture and Fixtures.

Respectfully submitted,

(Signed) ABEL REYNOLDS, *Treasurer.*

Boston, September 13, 1940

To ABEL REYNOLDS, *Treasurer,*

New England Water Works Association,
Providence, Rhode Island.

DEAR SIR:

We have examined the statement of assets and funds and the statement of cash receipts and disbursements of the general fund of the New England Water Works Association for the fiscal year ended August 31, 1940. In connection therewith we have reviewed the accounting procedures of the association and have

examined accounting records and other supporting evidence, by methods and to the extent we deemed appropriate.

We traced all recorded receipts into the depositary banks, verified the general fund bank account and petty cash fund as at August 31, 1940, and examined properly approved vouchers for all disbursements. We also verified by direct confirmation the investment funds on deposit in savings banks.

In our opinion, the accompanying statement of assets and funds and the note thereon and the related general fund cash statement present fairly the position of the New England Water Works Association at August 31, 1940, and the recorded cash receipts and disbursements for the fiscal year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

SCOVELL, WELLINGTON & COMPANY

Annual Report of the Editor

To the New England Water Works Association:

The Editor submits herewith the following report for the year ending August 31, 1940.

As has been customary in the past, the tables of financial figures, accompanying the report, are based upon total charges and accounts receivable, rather than actual cash received or disbursed. A detailed statement of the receipts and disbursements on account of the September and December, 1939, and March and June, 1940, issues of the Journal is included in the Report of the Treasurer.

Table 1.

Statement of Material in September and December, 1939, and March and June, 1940, Issues of the Journal of the New England Water Works Association.

Date	Papers	Proceedings	Total Text	Index	Advertisements	Cover and Contents	Insert Plates	Total	Total Cuts
September, 1939	137	1	138	0	41	5	0	184	13
December, 1939	120	32	152	11	41	5	0	199	15
March, 1940	143	6	149	0	41	5	0	205	50
June, 1940	109	17	126	0	43	5	0	174	19
Total	509	56	565	11	166	20	0	762	97

Table 2 gives a comparison of the Journal for the past year with preceding years.

Size. The four issues contained 762 pages, of which 565 were text.

Cost. The gross cost of the Journal was $3,846.46, equivalent to $4.83 per member; the net profit was $618.37, equivalent to $0.78 per member. Excluding reprints, the gross cost was $3,738.65, or $461.35 less than the estimate of the Finance Committee.

Reprints. Reprints of each paper have been furnished to the author at cost.

Circulation. The present circulation of the Journal is:

Members, all grades	801
Subscribers	143
Exchanges	23
Total	967

Journals have been sent to all subscribers and to 44 advertisers.

Respectfully submitted,

(Signed) Gordon M. Fair, *Editor.*

TABLE 2.

COMPARISON OF JOURNALS OF THE NEW ENGLAND WATER WORKS ASSOCIATION.
FOUR ISSUES FOR FISCAL YEAR ENDING AUG. 31.

	1931*	1932	1933	1934	1935	1936	1937	1938	1938	1940
Average edition (copies printed) .	1,260	1,200	1,125	1,100	1,100	1,100	1,100	1,100	1,000	1,100
Average membership	816	813	805	796	786	770	772	785	795	796
Circulation at end of year	955	957	930	928	918	903	920	943	946	967
Pages of text	410	437	420	499	470	477	435	510	488	565
Pages of text per 1,000 members	502	537	522	627	598	619	561	650	614	710
Total pages, all kinds	682	644	594	645	643	642	627	699	670	762
Total pages per 1,000 memebrs .	836	790	738	811	808	834	812	890	843	957
GROSS COST:										
Total	$6,135.33	$5,024.03	$4,712.16	$5,411.30	$4,780.75	$5,880.68	$5,040.86	$4,658.05	$4,119.30	$3,846.46
Per page	9.00	7.80	7.93	8.39	7.54	9.16	8.04	6.66	6.15	5.05
Per member	7.52	6.18	5.85	6.80	6.08	7.64	6.53	5.93	5.18	4.83
Per member per 1,000 pages ..	9.00	9.62	9.85	10.53	9.46	11.89	10.41	8.49	7.13	6.34
Per member per 1,000 pages text	18.34	14.30	13.94	13.62	12.93	16.01	15.01	11.63	10.61	8.55
NET COST:										
Total	$1,252.21	$1,121.20	$1,176.77	$1,916.27	$1,332.99	$1,499.58	$489.13	$539.21	$306.77†	$618.37†
Per page	1.84	1.74	1.98	2.97	2.07	2.34	0.78	0.77	0.46†	0.81†
Per member	1.53	1.38	1.46	2.41	1.70	1.95	0.63	0.69	0.39†	0.78†
Per member per 1,000 pages ..	2.24	2.14	2.46	3.73	2.64	3.03	1.01	0.98	0.58†	1.02†
Per member per 1,000 pages text	3.73	3.16	3.48	4.83	3.61	4.08	1.46	1.35	0.80†	1.37†

*Including comprehensive index, 1882 to 1930. †Profit.

Annual Report of the Finance Committee

Executive Committee,
New England Water Works Association
Boston, Mass.

Gentlemen:

The Finance Committee submits the following budget for 1940-1941:

Estimated Revenue

Initiation Fees	$ 100.00
Dues	5,300.00
Interest and Dividends	350.00
Journal	4,500.00
Miscellaneous	75.00
	$10,325.00

Estimated Expenditures

Office	$4,550.00
Journal	4,000.00
Meetings and Committees	1,450.00
Miscellaneous	150.00
	$10,150.00

In preparing the budget careful consideration was given to previous expenditures and adjustments made for non-recurring income or expenditures and additions made mainly for publication of a membership list ($475.00), Journal index ($100.00), and Cast Iron Pipe Specifications ($200.00).

The budget submitted appears to be slightly less than the estimated receipts of the Association.

An audit of the books by a certified public accountant will be found as a part of the Treasurer's Report.

(Signed) Harold L. Field, *Chairman,*
Theodore L. Cate,
Henry T. Gidley.

Annual Report of the Legislative Committee

Year Ending September 24, 1940

Mr. President and Members of the New England Water Works Association:

The Legislative Committee of the Association respectfully presents the following report of legislative affairs in 1940.

It is perhaps fortunate that regular sessions of the Legislatures were not held in New England this year except in Rhode Island, since appointments to the committee were not announced until after the most active part of the legislative season had passed.

The only action of interest to Water Works men in Rhode Island was an amendment to the water lien law. Under this amendment water districts and fire districts are granted the same privilege of putting liens on property for nonpayment of water bills as had previously been granted to municipal departments. Private water companies however were excluded from the act.

Respectfully submitted,

(Signed) Sidney S. Anthony,
Percy R. Sanders,
George A. Reed,
Harold W. Griswold,
James J. Dillon,
Leon A. Goodale,
Stephen H. Taylor,
Arthur C. King, *Chairman.*

Annual Report of Committee on Committees

This Committee was appointed by the Executive Committee of the Association, to promote coördination of committee activities in the Association and to promote the establishment of new technical committees where this seems advisable. This committee is an outgrowth of a Committee on Research and Water Works Practice which reported in 1939.

Present Standing Committees

Following the 1939 report, committees listed below were continued by vote of the Executive Committee with the addition of two committees appointed by President Shaw: (1) Committee for Survey of Ground Water Supplies in New England and (2) Investment Committee. Your Committee during the present year addressed a letter to all committee chairman and has received replies from all of the committees. Comments appear below on such activities of the committees as have been reported. In the appendix to this report is a list of the committee members. Inasmuch as this Committee's purposes are connected only with professional and technical activities of the Association, there are not listed the Annual Convention Committees nor such committees as the June Outing Committee and the Hospitality Committee, all of which play a large part in the social and promotional side of the Association.

Committee on New Members. This committee is active and contains representation from each of the New England states.

Committee on Finance. This committee is appointed by the Executive Committee annually in November, according to the Constitution, which also sets forth the duties of the committee in preparation of a budget.

Committee on Technical Program. This committee is, of course, a key committee.

Committee on Coefficients of Friction in Pipe Lines. No new developments are reported since the 1939 report of this committee, but the committee should be continued. A supplementary report is contemplated in the future.

Committee on Specifications for Cast Iron Pipe and Special Castings. This committee expects to report to the Association at the 1940 annual meeting. The committee should be continued.

Committee on Standardization of Pipe Flanges and Fittings. No new developments are reported since the 1939 report of this committee, but the committee should be continued.

Committee on Water Works Education. This is an active committee and should be continued. A report is expected at the 1940 annual meeting.

Committee to Investigate Grounding of Currents on House Plumbing. This committee is active and should be continued.

Committee on Sanitary Hazards of Interior Piping, Fixtures and Water Storage Within Buildings. This committee has done good work in keeping in touch with

other associations and committees who are working on improvement of design of plumbing fixtures and along other lines which are of importance in the water works field. While the present members of the committee feel that the committee might be discontinued for the present, your Committee on Committees is of the opinion that this is an important standing committee and should be continued.

Committee on Hydrant Specifications. It is expected that this committee will report in 1940 when it plans to submit a final report.

Committee on Meter Specifications. This commmittee expects to report in 1940 and should be continued until it has made a final report.

Committee on Emergency Procedures. This committee made an excellent progress report during the year and expects to report in 1940. Below under the heading "New Committees" is discussed the extension of activities in the field of National Preparedness.

Committee on Rainfall and Yield of Drainage Areas. It is expected that a progress report will be made in 1940. This committee should be continued.

Committee on Water Quality Tolerances for Industrial Uses. It is expected that a progress report will be made in 1940. This committee should be continued.

Committee on Library. This committee should be continued.

Publicity Committee. It is felt by your Committee on Committees that the Association can do a worth while job in publicizing the Association activities, not only from the standpoint of creating interest in the Association but also to carry to the public a better realization of the importance of the water superintendent's job. If necessary, a financial allotment should be made for activities of this committee. It is hoped that this work can be extended.

Legislative Committee. This committee should be continued.

Committee on Reciprocal Relations with the Institution of Water Engineers (England). This committee should be continued.

Committee on Survey of Ground Water Supplies in New England. This is a new committee and should have a report in 1941.

Investment Committee. This committee was appointed to review the methods of investing funds of the Association as a result of discussion at the last Annual Convention. The committee expects to make a final report in 1940 and should probably be discontinued thereafter.

Committee on Committees. This is the name of the committee submitting this report, and the continuance of the committee is recommended.

New Committees

Ground Water Supply Studies. This Association has made a start in promoting studies of ground water by appointing a committee to make a survey and report on ground water supplies in New England. Representatives of the various states are on this committee. It has been suggested that several aspects of the subject of "Ground Water Supplies" might warrant the attention of this or additional committees such as yield, quality, legal status, corrosive action, treatment, etc. It is recommended that the present Ground Water Committee consider these aspects and have in mind in its recommendations to the Association the advisability of appointment of additional committees.

National Preparedness. Already in many states, water works officials have given and are giving consideration to the importance of maintaining adequate and safe water supplies in the scheme of National Preparedness. In England and other war-torn countries, elaborate preparations have been worked out. It is recommended that either the Committee on Emergency Procedures be continued with a change of name or a new Committee on National Preparedness for Water Supplies be appointed. To be of value, this committee must be made up of active committee members who are interested to keep the Association membership promptly advised through progress reports.

Cathodic Protection of Steel Tanks and Standpipes. This form of protection of steel tanks and standpipes is meeting increased interest. It is recommended that consideration be given to the appointment of a committee to report on this subject to the Association. Attention should be given to the possible adverse effects from use of inferior equipment and the question of sanitary protection of water quality during and after installation of equipment.

Research. Your Committee feels that the possibility of the Association cooperating with various technical institutions in the New England area on research problems in the water works field should not be lost sight of. A committee on this subject containing representatives of these institutions might work out a worth while program. Financial assistance from the Association should be made possible if deemed advisable.

Corrosion and Remedial Measures. This subject is of interest to all water works engineers and superintendents. The formation of a committee to report on this subject has been discussed in the past. Even if such a committee confined its activities to an annual review of new developments in the field, its work would be of value.

Water Quality. It is understood that the United States Public Health Service has been engaged in studies of possible revision of standards for water supplies of interstate carriers. Inasmuch as these standards are widely used in passing on water quality, the Association might consider the advisability of appointing a committee on water quality.

Appointment of Committees

Objection is voiced by some committee members to the present policy of appointing committee members. This Association has followed a rather loose policy in the past. The appointment of certain committees such as the Finance Committee and the Nominating Committee is governed by the constitution. The appointment of other committees, however, is not so regulated and with every change in the presidency, there is considerable delay in the appointment of committee members, this often taking place to the extent of seriously handicapping committee activities during the current year.

It may be said that this can easily be taken care of by "jacking up" the President and the Executive Committee but this still remains a loose unsatisfactory arrangement because the responsibility is not definitely placed. Your committee, therefore, recommends that in order to place the appointment of committees on a definite basis, the constitution of the Association be amended to include the following:

"At the close of the Annual Meeting the new Executive Committee of the Association shall appoint or re-appoint the members of all standing professional and technical committees of the Association or shall delegate the duty of appointing any or all of such committees to the incoming President, except as otherwise provided in the Constitution. A list of all such committee members shall be forwarded to each committee member by the secretary in November. In case such appointments or re-appointments are to be made by the President, he shall notify the Secretary on or before the first week in November. During the month of November the secretary shall send a list of committee members to the Editor of the JOURNAL, who shall arrange for publication in the next issue of the JOURNAL. Interim committee appointments shall be made by the Executive Committee or as otherwise directed by vote of the Association, and notification of committee members shall be made by the Secretary within fifteen days after their appointment."

Recommendations

1. That existing committees be continued as discussed in this report.
2. That the work of the Publicity Committee be extended not only to give public notice of the activities of the Association but also to carry to the public a better realization of the importance of the water superintendent's job.
3. That new committees on National Preparedness and Cathodic Protection of Steel Tanks and Standpipes be appointed.
4. That further consideration be given to committee activities in connection with ground water studies, research, corrosion and remedial measures, and water quality.
5. That the constitution of the Association be amended, as outlined, to provide for a more effective method of committee appointments.

Respectfully submitted,

(Signed) WARREN J. SCOTT, *Chairman,*
THOMAS R. CAMP,
HARRY U. FULLER,
ARTHUR C. KING,
ARTHUR L. SHAW.

APPPENDIX.

LIST OF COMMITTEES OF NEW ENGLAND WATER WORKS ASSOCIATION

Committee on New Members

Harold L. Brigham, Chairman
Frederick O. A. Almquist
Sidney S. Anthony
George E. Hawkins
Abel Reynolds
Percy R. Sanders

Committee on Finance

Harold L. Field, Chairman
Theodore Cate
Henry T. Gidley

Committee on Technical Program

Samuel M. Ellsworth, Chairman
Sidney S. Anthony
Harold L. Brigham
E. Sherman Chase
Gordon M. Fair

Committee on Coefficients of Friction in Pipe Lines

Elson T. Killam, Chairman
Frank A. Barbour
William W. Brush
Charles W. Sherman

Committee on Specifications for Cast Iron Pipe and Special Castings
(Sectional Committee Under American Standards Ass'n.)

William R. Conard, Chairman
Arthur L. Shaw

Committee on Standardization of Pipe Flanges and Fittings
(Sectional Committee Under American Standards Ass'n.)

William R. Conard, Chairman
Frank A. Barbour

Committee on Water Works Education

Robert Spurr Weston, Chairman
Gordon M. Fair
Percy R. Sanders

Committee to Investigate Grounding of Currents on House Plumbing

George A. Sampson, Chairman
Warren A. Gentner
Arthur V. Harrington
Edward E. Minor

Committee on Sanitary Hazards of Interior Piping, Fixtures, and Water Storage within Buildings
(Joint Committee with American Water Works Association)

Stephen H. Taylor, Chairman
Arthur V. Harrington

Committee on Hydrant Specifications
(Joint Committee with American Water Works Association)

Roger W. Esty, Chairman
Harry U. Fuller
Harold W. Griswold

Committee on Meter Specifications
(Joint Committee with American Water Works Association)

Richard H. Ellis, Chairman
Warren A. Gentner

Committee on Emergency Procedures

Donald C. Calderwood, Chairman
Frederick O. A. Almquist
Percy C. Charnock
Richard H. Ellis
Linn H. Enslow
William P. Melley
Clarence I. Sterling

Committee on Rainfall and Yield of Drainage Areas

Arthur D. Weston, Chairman
Harold K. Barrows
Richard S. Holmgren
Harvey B. Kinnison
Elbert E. Lochridge
Arthur T. Safford
Caleb M. Saville
Charles W. Sherman
Miner R. Stackpole
James L. Tighe

Committee on Water Quality Tolerances for Industrial Uses

Edward W. Moore, Chairman
Stuart E. Coburn
Franklyn J. Lammers
Lewis Olney
Hervey J. Skinner
Robert S. Weston

Committee on Library

E. Sherman Chase, Chairman
Francis H. Kingsbury

Publicity Committee

E. Sherman Chase, Chairman
Francis H. Kingsbury

Legislative Committee

Arthur C. King, Chairman
Sidney S. Anthony
James J. Dillon
Leon A. Goodale
Harold W. Griswold
George A. Reed
Percy R. Sanders
Stephen H. Taylor

Commitee on Reciprocal Relations with the Institution of Water Engineers (England)

E. Sherman Chase, Chairman
Leland G. Carlton
Percy A. Shaw

Committee for Survey of Ground Water Supplies in New England

Leslie K. Sherman, Chairman
Joseph Knox
Howard H. Potter
Walter J. Shea
E. L Tracy
Leonard Trager

Investment Committee

Leland G. Carlton, Chairman
William P. Melley
Abel Reynolds

Committee on Committees

Warren J. Scott, Chairman
Thomas R. Camp
Harry U. Fuller
Arthur C. King
Arthur L. Shaw

Report of the Committee on Investments

Mr. President and Members of the New England Water Works Association:

At the last Annual Convention of the New England Water Works Association, the President was empowered to appoint a Committee to review the investment program of the Association, with the thought that its revenue funds might be invested in some form of securities which would net the Association a larger return than that received under the present scheme of investment.

The reserve funds in question, consisting of $18,068.46, at present are deposited in nine savings banks in central and eastern Massachusetts, all of which have an interest rate of 2%. For several years, the interest received from these deposits has been combined with the regular receipts of the Association and used to defray expenses, and until last year, without this interest there would have been a deficit, such as actually did occur in 1936. However, in 1939 the receipts exceeded the expenditures by an amount larger than the interest received.

With these facts to work on, the Committee decided that inasmuch as its members lived in three well separated localities, each member should consult reliable authorities in his area, such as Trust Officers, Investment Bankers and Brokers to obtain their opinions on this question, and report his findings at a later meeting.

Conferences were held by the Committee at the monthly meetings of the Association and opinions similar to the following were submitted by its members:

That the Association's reserve funds are in reality trust funds, and if invested, consideration should be given only to the highest grade securities, such as triple A bonds.

That triple A bonds would yield a low net return at their present premium prices.

That savings banks would react to an upturn in the business trend, by raising their rates of interest on deposits.

That with such an upturn would come new issues of bonds carrying higher rates of interest, resulting in a lower market price for present day bonds.

That in the purchase of United States Savings Bonds, the full rate of interest would not be realized until after a period of ten years, thereby sacrificing the possibility of having the interest available to defray expenses should occasion again require, as in the past. Under a recent ruling by the Treasury Department, these bonds are now available to individuals only.

Based on opinions obtained, and they are of course only opinions, the Committee on Investments recommends that the reserve funds of the New England Water Works Association remain, for the present at least, on deposit in the various savings banks.

Respectfully submitted,

Committee on Investments
(Signed) William P. Melley,
Abel Reynolds,
Leland G. Carlton, *Chairman.*